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## **Development of a Geomorphology-Based Framework for Cultural Resources Management, Dworshak Reservoir, Idaho**

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# Preface

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This work was performed during the period July 1993 through March 1995 at the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS, for the U.S. Army Engineer Districts, Walla Walla (NPW), and Portland (NPP). The project was conducted in support of the Columbia River Systems Operation Review (SOR).

The project research and development and report preparation were performed by Ms. Maureen K. Corcoran and Dr. Lawson M. Smith, Engineering Geology Branch (EGB), Earthquake Engineering and Geosciences Division (EEGD), Geotechnical and Structures Laboratory (GSL), and Dr. Paul R. Nickens, Resource Analysis Branch (RAB), Natural Resources Division (NRD), Environmental Laboratory (EL). General supervision was supplied by Mr. Roger Hamilton, Chief, RAB, Dr. Robert M. Engler, Chief, NRD, Dr. Edwin A. Theriot, Acting Director, EL, Mr. Joe Gatz, Chief, EGB, Dr. Arley G. Franklin, Chief, EEGD, and Dr. Michael J. O'Connor, Director, GSL.

Mr. John Leier, NPW, and Ms. Lynda Walker and Mr. Jay Sturgill, NPP, were the technical monitors for the project. Additional direction and guidance was provided by Mr. William Willingham, NPD, and Dr. David Rice, NPS.

At the time of publication of this report, Dr. James R. Houston was Director of ERDC, and COL John W. Morris III, EN, was Commander and Executive Director.

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# 1 Introduction

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## Background

The Columbia River and its tributaries are the primary water system in the Pacific Northwest, draining some  $5.67 \times 10^{11}$  sq m (219,000 square miles) in seven states and another  $1.02 \times 10^{11}$  sq m (39,500 square miles) in British Columbia. Beginning in the 1930s, the Columbia River has been significantly modified by construction of 30 major dams on the river and its tributaries, along with dozens of non-Federal projects. Construction and subsequent operation of these water development projects have contributed to eight primary uses of the river system, including navigation, flood control, irrigation, electric power generation, fish migration, fish and wildlife habitat, recreation, and water supply and quality considerations.

Increasing stress on the water development of the Columbia River and its tributaries has led primary Federal agencies to undertake intensive analysis and evaluation of the operation of these projects. These agencies are the U.S. Army Corps of Engineers and the Bureau of Reclamation, who operate the large Federal dams on the river, and the Bonneville Power Administration, who sells the power generated at the dams. This review, termed the System Operation Review (SOR), has as its ultimate goal to define a strategy for future operation of the major Columbia River projects, which effectively considers the needs of all river uses.

The SOR analysis is concentrating on 14 dams and hydroelectric projects that play a key role in the multipurpose use of the river system. These dams include five Federal Columbia River System storage dams: Hungry Horse, Libby, Albeni Falls, Grand Coulee, and Dworshak, and nine downstream run-of-river projects: Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. Together, these projects include a variety of dams and reservoirs, navigation channels and locks, hydroelectric power plants, high-voltage power lines and substations, fish ladders and bypass facilities, irrigation diversions and pumps, parks and recreation facilities, boat launches, administrative lands, and areas set aside to replace wildlife habitat.

As indicated above, the projects under review fall into two distinct categories: storage and run-of-river. The difference between the two types is important for the analysis undertaken in this report, particularly in terms of operating water level fluctuations.

Storage reservoirs adjust the river's natural flow patterns to fit more closely with water uses. Since precipitation is unevenly distributed throughout the year, these reservoirs capture runoff when it is heavier and store it for use during periods of lesser runoff. Generally, this means that plentiful spring runoff is captured and then released for multiple uses in the late summer, fall, and winter. Some of the Columbia Basin dams have large capacities for capturing runoff and storage, meaning that sometimes significant variations occur in the operating water levels. For example, Hungry Horse operates over a range of 68.3 m (224 ft); Libby, 52.4 m (172 ft); Dworshak, 47.2 m (155 ft); and Grand Coulee, 25 m (82 ft).

In contrast, run-of-river projects have limited storage capabilities, having been constructed primarily for navigation needs and power generation. Reservoir levels at these projects usually vary only 0.9 to 1.5 m (3 to 5 ft) during normal operations.

The SOR analysis involves a number of uses and resources that need to be considered, particularly under options that may change the operation of projects in the system. One category of resources that may be affected by changing operation activities is cultural resources. The riverbanks and shorelines in the Columbia River System contain many hundreds of significant archaeological and historical sites that form a record of past human occupation and use of the region extending back some 10,000 years. Often, these fragile resources represent our only clues to many aspects of this long cultural heritage.

Even under normal project operating conditions, historically these sites have been subjected to reservoir-related impacts such as physical and chemical impacts related to lowering and filling of lake levels and wind and wave erosion causing bank line recession. In addition, secondary impacts arise from recreation and other land use activities, as well as the ever-present threat of vandalism and looting of sites.

Some options being explored in the SOR analysis for the Columbia River System will likely lead to increased potential for additional reservoir-related impacts to cultural resource sites as they are further physically modified by either erosional or depositional geomorphic processes brought about by additional drawdown and filling activities at the projects. Moreover, increased exposure of sometimes or previously inundated cultural sites and artifacts will probably cause an increase in incidences of site vandalism and artifact collecting.

In order to provide necessary information for the SOR analysis, as well as fulfill the legal responsibility of Federal agencies to protect and preserve significant cultural resources at the projects under review, it is essential that a comprehensive framework be developed for addressing ongoing and subsequent impacts to these resources. To meet this need, the SOR Cultural Resources Study Group, working through the U.S. Army Engineer Districts, Portland and Walla Walla, requested the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS, to develop working procedures for assessing potential impacts to cultural resources from changing operating conditions, monitoring the effects of those impacts, and evaluating and selecting efficient and cost-effective long-term protective measures.

## Purpose and Objectives

The overall purpose of this study is to develop a “technical framework” that includes those aspects of the management process for identifying, evaluating, and mitigating physical impacts to cultural resource sites affected by reservoir operation activities in the Columbia River System. The framework has been defined to consist of three procedures (Figure 1). These include: (1) an analytical geomorphic procedure that can be used to identify both the types of ongoing erosional processes and how these might change under various SOR options; (2) a resource monitoring procedure for collecting critical long-term data on changing conditions in resource integrity; and (3) a site protection procedure that can be used to evaluate and identify appropriate long-term preservation strategies.

The procedures developed for this framework must be somewhat generic in scope to account for the geomorphic and cultural variability that may be expected to occur throughout the entire Columbia Basin. Furthermore, the procedures need to be flexible enough to be applicable to both storage and run-of-river reservoirs. On the other hand, it was felt that development of the procedures could best be undertaken in relation to specific field settings. Two reservoirs, Dworshak on the Clearwater River in Idaho (a storage reservoir), and John Day, a run-of-river reservoir on the lower Columbia River between Washington and Oregon, were selected as case studies for the prototype procedures. Both are Corps of Engineers projects.

Originally, separate study tasks were outlined for both Dworshak and John Day Reservoirs. It soon became apparent, however, that there was considerable overlap in developing procedures for the two projects and that some combination of effort was necessary. Thus, several more specific objectives are the focus of the following analysis. These include:

- a. An analytical geomorphic procedure for use in management of cultural resources in the Columbia River System will be proposed. The primary function of the procedure and its application is to provide the necessary information for developing site monitoring and protection plans for cultural resources in impact zones of reservoirs throughout the basin.

The conceptual geomorphic procedure will be based on a review of geologic and geomorphic conditions at both Dworshak and John Day Reservoirs, although the data for Dworshak will be used to prepare a project-specific analysis of the effects of reservoir operations on extant cultural sites. The procedure will be developed such that it may be exported to other reservoirs in the Columbia River System.

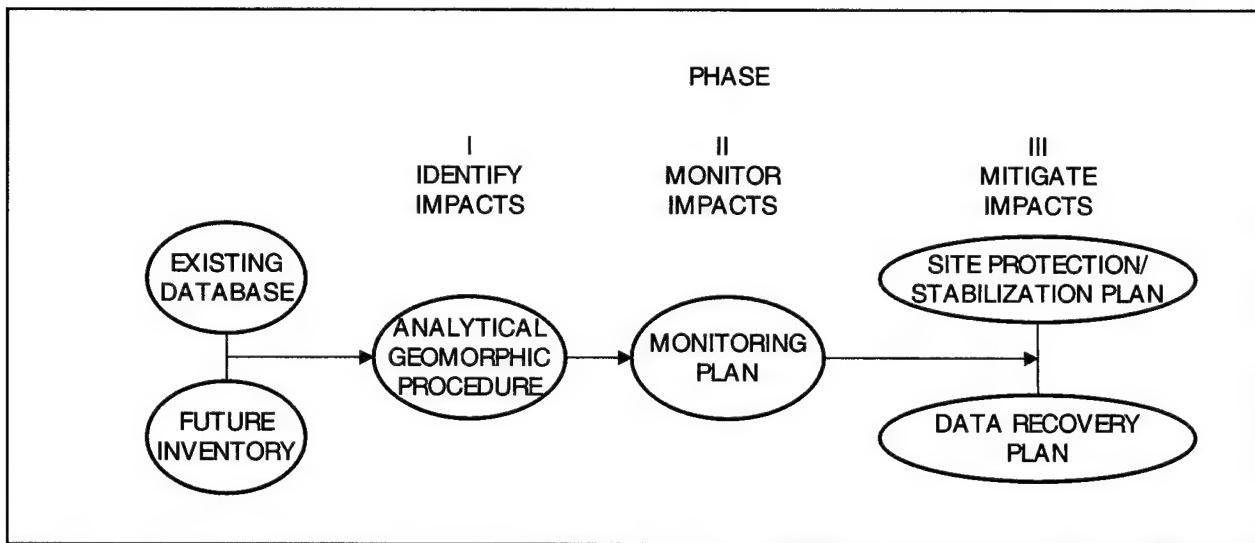


Figure 1. Technical framework of the management process

- b. A site monitoring procedure, which is also generic in scope, will be offered that incorporates these aspects:
  - (1) Development of objectives for a cultural site-monitoring program with emphasis on monitoring impacts in the fluctuating water zones at reservoirs.
  - (2) Identification of critical attributes to be monitored in order to meet the objectives.
  - (3) Development of a general methodology and array of techniques for monitoring these attributes.
  - (4) Specifications provided for implementing the monitoring program, along with a format for storing, analyzing, and reporting the results.

The existing cultural resource database for John Day Project will be used to formulate a pilot-monitoring scheme.

- c. A proposed procedure for evaluating alternatives for cultural site protection and long-term preservation will be presented. The site protection procedure will focus on cultural sites at Dworshak Lake where the geomorphic procedure has also been developed using those field data.
- d. As discussed above, the final objective of this effort is to ensure that the procedures for addressing reservoir operation-related impacts to cultural resources are applicable in other regions along the Columbia River. The procedures have been developed for two substantially different reservoir settings in Dworshak and John Day and, therefore, are designed to deal with a variety of landscapes and cultural site conditions. For these

reasons, the procedures should be readily adaptable to other reservoirs in the Columbia River System when local conditions are considered.

## **Organization of the Report**

Following the introductory comments, Chapter 2 provides a general review of management concerns associated with reservoir-related impacts to cultural resource sites, with particular emphasis on those situated along the shoreline. Chapter 3 serves to establish the geomorphic and cultural settings for the procedures comprising the technical framework. In Chapters 4 through 6 the geomorphic, monitoring, and site protection procedures are presented, respectively, using the Dworshak and John Day project data as examples.

## **2 Reservoir Operations and Impacts on Cultural Resources**

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### **General**

Construction and operation of reservoirs by various Federal and state agencies and other proponents have created significant adverse impacts for archaeological and historical resource properties. Initially, these impacts primarily involve those associated with construction activities, filling, and subsequent inundation.

Following reservoir filling, impacts on cultural resources come from various sources associated with physical processes and use of the adjacent land.

Adequate mitigation of impacts on cultural resources located along the shorelines at reservoir projects over the years has ranged from none at all for some older projects to only partial mitigative efforts at others. Various factors have limited the effectiveness of mitigation efforts, including a lack of adequate protective legislation at the time of project authorization and construction, or simply insufficient funding and time for satisfactory resource identification, evaluation, and data recovery undertakings. Additionally, the nature of the resource base itself can be a hindrance (significant portions of the earlier prehistoric/historic record may be buried and therefore not easily observed) and important improvements in the methods and techniques for identifying and studying cultural resources have occurred over the past several decades. Significant changes in approaches for managing and protecting such resources have also taken place in recent years.

The consequence for today's resource managers is that significant portions of the once extensive cultural resource record still remain at many, if not most, operating reservoir projects. Management and protection of this resource remains an important responsibility. Among the various ongoing impacts that threaten sites at these projects, those associated with physical processes, such as shoreline erosion and bank line recession, are easily the most prevalent and most damaging to the resource base.

To provide a background for the technical framework presented in the following chapters, this section provides a brief overview of reservoir-related

impacts to cultural resources, with emphasis on those impacts that occur in the fluctuation zone. Some relevant information from earlier studies in the general study area is also summarized. A more detailed examination of geomorphic impacts on cultural resources will be presented in Chapter 4.

## Reservoir Impacts on Cultural Resources

As noted, the construction and operation of reservoirs include a wide range of potential impacts on cultural resource sites, ranging from full inundation (and possible long-term preservation) to others of a more devastating nature. In order to investigate the character of these impacts, a multiagency (National Park Service, Bureau of Reclamation, and Corps of Engineers), 5-year research effort was completed in 1980 (Lenihan et al. 1981). This project, known as the National Reservoir Inundation Study (NRIS), examined reservoir-related impacts on cultural resources. Much of the following discussion is taken from the original NRIS study and a recent summary of the overall effort (Ware 1989).

To facilitate analysis of the various reservoir-related impacts that might affect cultural resource sites, the NRIS subdivided a typical reservoir impoundment into five impact zones, the most critical of which are the conservation pool, the fluctuation or drawdown zone, and the backshore zone. For the purposes of this report, we will concentrate on the fluctuation zone.

The NRIS also identified three categories of processes that affect the preservation of cultural resources in reservoirs and waterways: (1) mechanical or physical; (2) biochemical; and (3) human and other processes. Mechanical processes include the physical erosion and deposition processes associated with a large body of water. In reservoirs, wave action was the most important mechanical impact on cultural sites. Wind-generated waves are the most common, but destructive waves can also be generated by powerboat wakes and tectonic disturbances.

On run-of-river pools, navigation-related impacts also have great potential for creating considerable erosion of cultural resources located on the banks (Gramann 1981). Here, several types of impact have been identified that contribute to bank erosion and potential loss of resources, including barge traffic, pool manipulation, recreational use, structural features such as wing dams and levees, and mooring of barges near shorelines.

The chemical and biological environment of a reservoir is of primary concern for the differential preservation and destruction of inundated cultural materials. These processes are particularly critical in the fluctuation zone. Changes at rock art sites located on geologic strata near the waterline serve as a good example of these processes. In this case, such impacts can include chemical changes leading to deterioration of the stone matrix, growth of algae, deposition of resource-obscuring silt or calcium deposits (the ubiquitous reservoir "bathtub ring"), or simply deterioration of pigments used to create the aboriginal artwork.

The final category of impacting processes, human and other, includes the myriad consequences of human activities, ranging from dam construction to cultural site vandalism and looting, and impacts associated with changes in land use following dam construction and reservoir impoundment. While most of these impacts may occur primarily in the backshore zone, many such activities take place near the waterline and increase the possibility for erosion or destruction of cultural resources. An example is the opportunity for easy access to archaeological sites via boat, when such access had been difficult prior to reservoir filling. Where fluctuating waterlines exist, many of these activities have a tendency to follow the waterline, thereby creating hazards for freshly exposed sites.

Another way to characterize reservoir shoreline impacts to cultural resources is in terms of primary and secondary impacts. Put another way, there are a number of secondary impacts that are created or made possible by the presence of a primary impact such as shoreline erosion and bank line erosion. In most cases, these secondary impacts exacerbate the situation and hasten the loss of both the substrate and the resource sites. Some of these secondary impacts include burrowing of animals and birds in exposed cutbanks which further contributes to bank instability, undercutting and subsequent falling of large trees, vandalism of previously hidden cultural artifacts and features, and wind or solar erosion of exposed artifacts, particularly items of bone.

## **Impacts on Cultural Resources in the Fluctuation Zone**

In searching for evidence of damage or destruction to cultural resources located along the shorelines of reservoirs, it is necessary to go beyond examination of only the erosion occurring at the waterlines and look, rather, at the total fluctuation zone. In some cases, this may be only a 0.3- to 0.6-m (1- or 2-ft) zone; in other instances, the fluctuation zone may be upwards of 61 m (200 ft).

Normally, the fluctuation zone is determined by operational considerations and is somewhat standardized annually, although special circumstances can greatly alter the situation. Recent examples of significant changes in normal operating drawdown procedures include the drought-caused drawdowns along the Middle Missouri River and intentional test drawdowns along the Snake River in 1992. Other special drawdowns have occurred in conjunction with compliance with the Dam Safety Act, or other modifications of dam structures. Alternatively, some conservation pools may actually be raised in the future. Such might be the case, for example, where generating units are added at dams where the original construction plans included blockouts for additional units.

One of the most critical data gaps for cultural resource managers at reservoirs is associated with identifying, evaluating, and preventing erosion to sites situated in the drawdown zone. Loss of sites and cultural materials due to mass failures along a cutbank is easily recognized and measured. Slower, more gradual loss of cultural sites due to fluctuating water levels is much more difficult to visualize

and record, although this form of erosion may be even more damaging since it affects a larger area. On a smaller scale, there are very few detailed studies of hydrologic artifact dispersals, such as erosion, transport of materials, and redeposition, and other nonhuman transposition processes. A recent example of the importance of the need for careful consideration of the effects hydrological artifact dispersal and sorting on site patterns is found in Reinhardt (1993).

Within the shoreline fluctuation zone of most reservoirs, virtually all categories of the impacts discussed above are intensified, with mechanical hydrological impacts constituting the greatest threat to cultural resources. Lenihan et al. (1981) concluded that wave action in this zone created the most serious impacts to cultural sites. The nature and extent of these erosional and depositional impacts are influenced by four variable conditions:

- a. Reservoir size, depth, and orientation, hydrological characteristics of the watershed, local climatic regime, and the operating characteristics of the reservoir.
- b. Location of the cultural resource site relative to reservoir fetch and prevailing wind patterns.
- c. The geological and environmental context at the site (especially the slope and erosion resistance of the geomorphological substrate).
- d. The character and erosion resistance of the cultural deposits themselves.

In addition to the high-energy impacts of waves in the fluctuation zone, frequent wetting and drying of cultural deposits on the shoreline poses a significant threat to a wide variety of cultural materials (e.g., bone, pollen, and other organic items).

In addition to the prevalent mechanical impacts, the fluctuation zone also experiences significant biochemical impacts. Biochemical activity is accelerated in the shallow waters of the reservoir littoral zone because of higher light, dissolved oxygen levels, and ambient temperatures. These conditions will support more organisms that may cause deterioration of perishable cultural materials. Moreover, the potential for human and faunal impacts is greatest in the fluctuation zone because of increased activity along the reservoir waterline.

## **Reservoir Shoreline Impacts to Cultural Resources in the Lower Columbia Basin**

For this discussion, the Lower Columbia Basin includes reservoir projects on the Columbia River and its tributaries located in the U.S. Army Engineer Districts, Portland and Walla Walla. More specifically, the projects are found on the Lower Snake River and its tributary the Clearwater River, in addition to the Columbia itself. Over the past 20 years or so, several field studies have called attention to the impacts of reservoir operation on cultural resources located along

lake shorelines in this region. Some of these investigations are reviewed below to highlight the extent of the problem for resource managers.

Reservoir-related impacts to prehistoric and historic sites in the Lower Columbia Basin were documented beginning about 20 years ago along the Snake River below Lewiston, ID. Here, construction and filling of the Lower Granite project was preceded by research on cultural resources. In addition to the standard resource identification, evaluation, and mitigation efforts, some pioneering research was conducted in two areas of interest to the present study. The first was an analysis of the geomorphic setting of the impending reservoir area, with special reference to its relationship to archaeological chronology and site location (Hammatt 1976). Hammatt's study described the correlation between geomorphic and human settlement patterns that existed prior to dam construction. Today they exist in an altered state below the reservoir waterline. This kind of baseline information is not found at the other reservoir projects in the region.

The second set of useful observations was made by David Brauner et al. (1975) as the Lower Granite Dam pool was raised in early 1975. This study undertook three important tasks, including final observations of remaining cultural site conditions after dam construction but before inundation, field observations of the immediate impact of the reservoir filling on the sites, and, finally, using these findings to provide recommendations for site preservation in future cases of a similar nature.

Prior to inundation, Brauner and his co-workers visited remaining sites to take photographs and make observations on vegetative cover, sediment types, slope, and previous forms of disturbances on or near the sites. Also, 50-cm (19.7-in.) interval stake lines were implanted on the sites to document the amount of slump caused by the rising water. The reservoir filling took 4 days to reach operating pool level. During this period, the researchers made daily monitoring trips by boat to the sites to record current conditions.

Based on this work, Brauner et al. (1975) observed the effects of rising water on different types of sediments and landforms, and noted site-specific effects on selected cultural resource properties. The most serious impacts to sites observed were caused by water saturation and wave action on the talus slopes, alluvial fan gravels, high-angle gravel deposits, and truncated portions of gravel bars. In this case, however, the investigators noted that damage to remaining sites from reservoir filling was far less than damage from construction activities such as quarrying and clearing.

The authors suggested that future preinundation cultural resource studies should include predictive analyses about the postinundation condition of archaeological sites. The predictive approach should take into account local site-related factors such as topographic position, sediment types, vegetation cover, and previous disturbance coupled with estimated angle of repose data.

In recent years, cultural resources investigations associated with drawdowns at some reservoirs have combined to contribute good information on past and ongoing impacts and site condition in fluctuation zones. The most important of

these efforts are two conducted by the Center for Northwest Anthropology at Washington State University (Draper 1990, Center for Northwest Anthropology 1992). The reports of these two projects contain much useful data on impacts to cultural sites in both inundated conditions and zones of fluctuating water levels. Only a brief discussion of the findings is given here. Interested readers should consult the reports for additional information.

In 1989, a maximum 36.6-m (120-ft) drawdown of Dworshak Lake occurred, allowing an opportunity to conduct field investigations of the area affected by reservoir operations. Coverage of about two-thirds of the exposed reservoir drawdown zone resulted in the recording of 166 archaeological sites (Draper 1990). These sites were previously unknown but had been impacted by reservoir operation activities since 1971. Although assessment and geomorphic evaluation of reservoir impacts to cultural resource sites was not included in the project research design (Draper 1990), standard field observations of site condition allowed some general conclusions regarding impacts to sites from reservoir operations, based on surficial examination only. A planned testing phase that would have added critical data on site condition and level of destruction was not completed due to weather and logistical problems.

Based on the surface indications, Draper believes that about 25 percent of the 166 sites have been completely eroded by reservoir operations, another 50 percent have been substantially eroded (i.e., more than 50 percent destroyed), and about 39 percent fall into a partially eroded category (i.e., less than 50 percent eroded). The remaining (11 percent) newly exposed sites occur near the high waterline. He does caution, however, that many of the substantially and partially eroded sites may have undisturbed but obscured cultural deposits lying above the high waterline.

While field survey of drawdown zones will always record some level of damage to archaeological sites, Draper does note a positive aspect in that the visibility of the ground surface and the sites is significantly enhanced by reservoir operation. In fact, he observes that the exceptional visibility undoubtedly yielded a more representative sample of sites than would have been possible under preinundation intensive survey procedures. This can be used to argue that managers' site identification and evaluation responsibilities should not end with preconstruction surveys and mitigation actions. Access to drawdown zones and banklines in recession should be viewed as an opportunity for acquiring additional primary cultural resource data on a continual basis during reservoir operation.

The second effort was also directed by John Draper (Center for Northwest Anthropology 1992) and involved field assessments of several previously inundated prehistoric and historic sites during a test drawdown of Lower Granite and Little Goose Reservoirs on the Snake River. The drawdowns took place during a 1-month period in 1992. The field effort also included inspections of a number of sites along the John Day Reservoir shoreline, although there was no drawdown at this project.

The scheduling of the test drawdowns of the Snake River reservoirs created logistical problems for the field effort since the drawdown began on March 1,

1992, reaching minimum pool level at the middle of the month, followed by refilling so that the pools were refilled by the end of the month. Thus, the exposure of inundated sites was relatively brief, and uncovered sediments had little time to dry out.

The opportunity to examine sites both in the normal fluctuation zone and the usually inaccessible conservation pool provided a unique opportunity to acquire information on not only site conditions but reservoir lowering and filling impacts as well. It also allowed for new or altered significant evaluations in terms of National Register of Historic Places eligibility criteria and the formulation of recommendations for future management of the sites.

Although limited by time and funding constraints, this effort is useful because it represents the only such information available on the physical effects of larger than normal drawdowns. Critical baseline data (topographic maps, photographs, and other observations) also were collected for those sites examined during the drawdowns at Little Goose and Lower Granite Reservoirs. The field inspections of 31 archaeological sites at John Day Reservoir resulted in only brief descriptions of the current conditions of the sites.

## **Summary**

Adverse effects to archaeological sites from operation of reservoirs are both episodic and cumulative. Because such impacts occur throughout the operation cycle, including daily, monthly, and annually, as well as throughout the overall life of the reservoir, it is hard to achieve complete understanding of the processes involved or the duration and magnitude of the loss. Critical observations pertaining to rate of loss at individual archaeological sites are difficult to make on a reservoir-wide basis because of logistical and funding constraints. Partial and incomplete snapshots are sometimes achieved, such as those discussed above for the Snake and Lower Columbia River projects. Comprehensive long-term management strategies for understanding the problem and acquiring much-needed data on processes and loss of cultural information and sites are not currently available to resource managers. The ensuing chapters describe recommended procedures for meeting long-term management needs to reduce reservoir impacts on cultural sites.

## **3 Geomorphic and Cultural Settings of the Study Areas**

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This chapter provides a setting for the geologic and cultural features of the general region and the two Corps of Engineers reservoir projects that have been selected for analysis.

### **Major Geological Controls of the Columbia River Basin**

The Columbia River drains  $6.71 \times 10^{11}$  sq m (259,000 square miles) of the Pacific Northwest and is bounded by the Rocky Mountain system on the east and the north, the Cascade Range on the west, and the Great Basin on the south. The geologic history of the Columbia River and its tributaries represents a series of complex events. In early Oligocene and Eocene, a terrestrial formation eroded to a stable, mature surface. Successive episodes of volcanic eruption during Miocene time resulted in the formation of basalt (Hodge 1938) and covered a large physiographic province referred to as the Columbia River Plateau. Sufficient time separated these eruptive episodes for the interbedded ash to be weathered to a fertile soil. Volcanic material erupted during the close of the volcanic stage (Late Miocene) and covered much of the basalt.

Faulting, on both small and large scales, fractured the basalt and influenced the course of the Columbia River. The Columbia River flowed over the basalt along faults and weak zones cutting V-shaped valleys along its path. Volcanic activity continued during the middle Pliocene restricting stream activity but not entirely diverting the ancestral Columbia River. Successive lava flows did dam the river many times producing lakes and lakebeds. During and after the volcanic periods (Miocene and Pliocene), the earth's crust was in a state of unstable equilibrium. Upheaval and downwarping of the basalt persisted, accelerating erosion and influencing the distinctive grid pattern of the streams. The lava was deposited over a terrain of considerable relief resulting in elevation variations of the lava from place to place. These Miocene and Pliocene basalt deposits are collectively referred to as the Columbia River Basalts and are found at an average depth of 914.4 m (3,000 ft).

The Columbia River has maintained basically the same course since its origin. Catastrophic flooding, referred to as the Spokane floods, occurred during the Late Pleistocene after an ice dam at glacial Lake Missoula in Montana burst and released water downstream influencing the appearance of the Columbia River and its tributaries. The last series of these catastrophic floods occurred about 15,000 to 12,800 years ago but its effect on the topography has been profound.

Glacial activity throughout the Pleistocene produced much of the rugged topography of north and central Idaho. Some streams deepened their channels thousands of feet during this time. A seaward tilting of the entire western Oregon-Washington area during a glacial epoch drowned the mouth of the Columbia River. This submergence produced a series of landslides along the walls of the gorge bordering the river.

The geologic history of the Columbia River Basin has produced a variety of geomorphic settings in the Columbia River System. Like most large river systems, the Columbia System begins as relatively steep tributaries in narrow valleys and grade down valley into large streams of lower gradients in large alluvial valleys. However, unlike most streams, the lower Columbia River Valley is largely a relic of catastrophic events, which in no way reflect modern conditions and processes in the Columbia River Valley. Consequently, the geomorphic settings of Dworshak and John Day Reservoirs are substantially different, the former on a major tributary, the latter in the lower Columbia River Valley (Figure 2).

## Dworshak Reservoir

### Geomorphic setting

Dworshak Reservoir is located on the North Fork Clearwater River, a tributary of the Clearwater River, in the Lower Snake River Basin (Figure 3). The river and its tributaries drain approximately 3,926.8 km (2,440 miles) of the geomorphic provinces of the northern Rocky Mountain and the Columbia Intermontane Basin (Draper 1990). Hubbard (1956) referred to a local physiographic unit trending parallel to the Clearwater River as the Clearwater Escarpment, a structural downwarping of the basalts and interbedded sediments at angles of as much as 60 deg on the face of the slope.

Impounded in a relatively narrow and steep valley, fluctuation of the reservoir level by as much as 45.7 m (150 ft) over moderately steep mountainsides provides many opportunities for substantial erosion and deposition of surficial soils and sediments by geomorphic processes. Reconnaissance of the Dworshak shoreline reveals many areas where geomorphic processes are rapidly removing the native soils or, in some cases, depositing eroded soils on lower slopes. Periodic inundation, saturation, and subsequent exposure and drainage of the soils along a fluctuating reservoir shoreline have already had a profound impact on the integrity of cultural resources in the Dworshak Reservoir area.

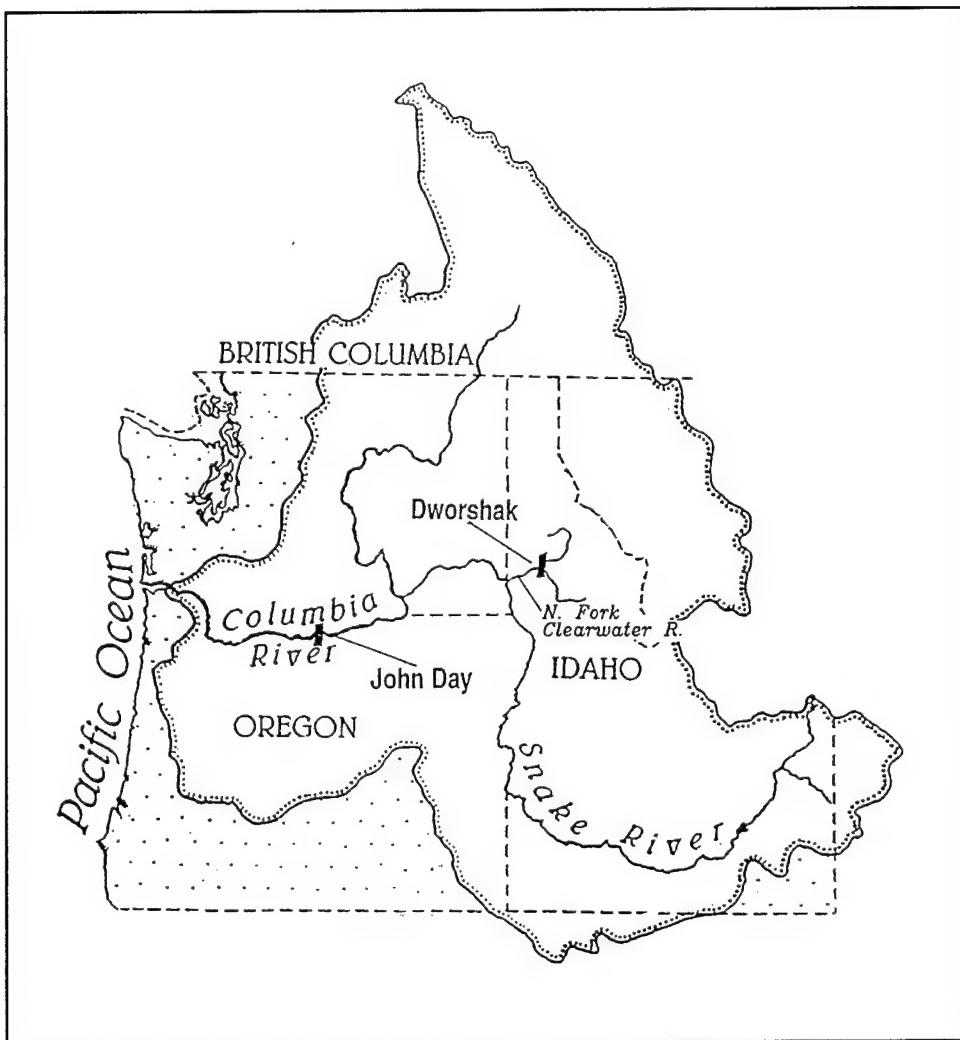


Figure 2. Area map of Dworshak and John Day Reservoirs

Prior to the impoundment of Dworshak Reservoir, a profile of the Clearwater Valley consisted of steep mountain and hillsides grading down to one or more river terraces at various elevations above a narrow floodplain in the base of the valley. Near Dworshak Dam, fluctuation of the reservoir results in transgression of the shoreline across steep mountain and hillsides. With increasing distance up the reservoir, the prism of reservoir fluctuation intercepts lower mountain and hillsides, river terraces, and eventually the floodplain.

### Cultural setting

Cultural resource investigations have been conducted at Dworshak Reservoir beginning in 1961 and continuing to the present. The individual project focus and results of these past efforts, as well as delineation of the area's cultural history, have been published previously (e.g., Mattson 1983 and Draper 1992). Today, 215 archaeological sites have been identified in the reservoir and adjacent Corps

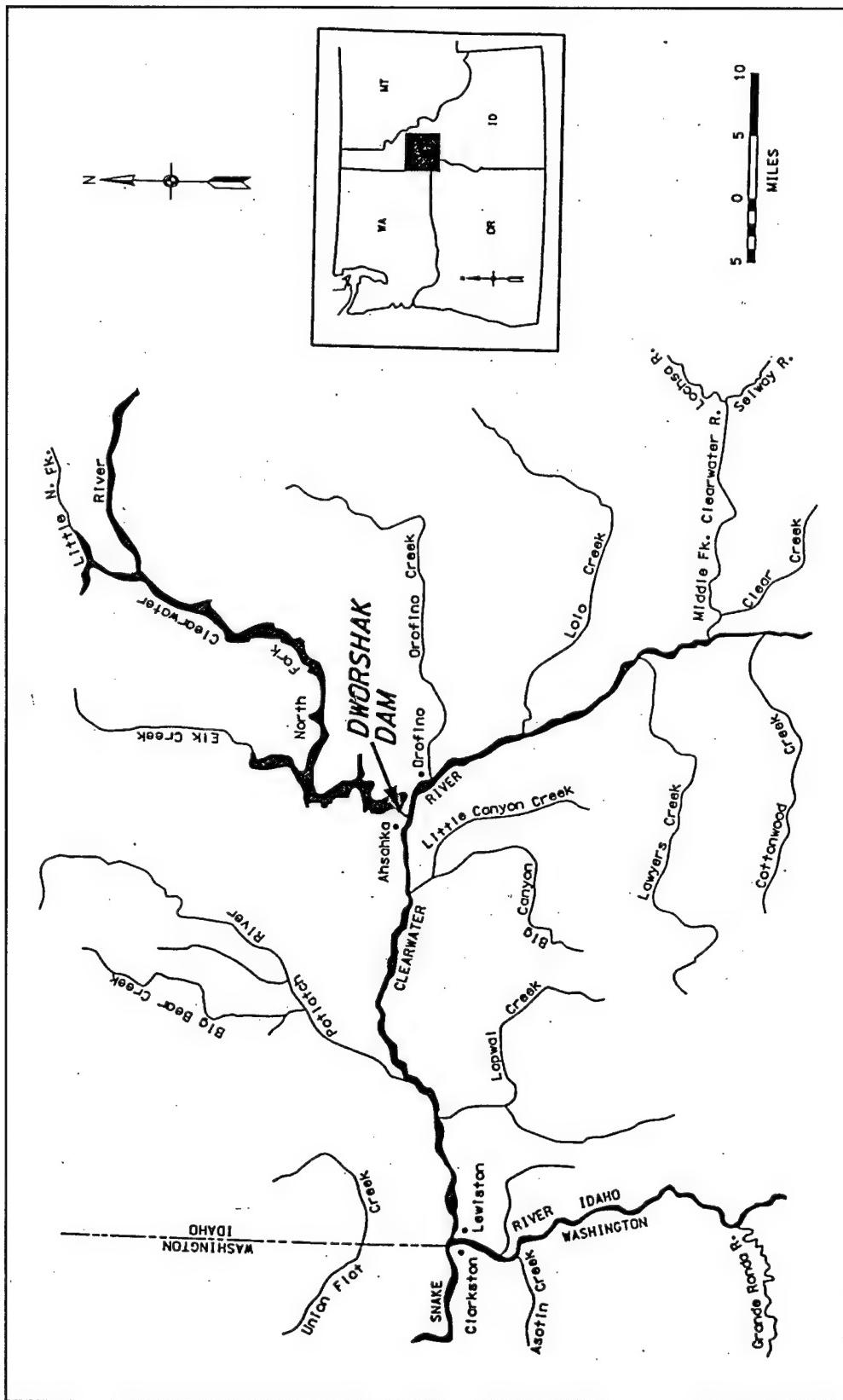


Figure 3. Location of Dworshak Reservoir, North Fork Clearwater River, Idaho

lands. Results of these projects and interpretations of the data indicate Native American habitation of the valley extending to 10,000 years ago, including intensive use of the region by the historic Nez Perce.

During the most recent cultural resources survey of the reservoir fluctuation zone in 1989 (Draper 1992), some 170 archaeological sites were identified and recorded, 166 of which had not been previously recognized. Of this total, 160 sites are Native American in origin, another six have both aboriginal and historic Euroamerican components, and four have only Euroamerican occupation debris. This survey did not include Corps' administrative lands above the high water elevation (487.7 m (1,600 ft)) and a total of 33.8 km (21 miles) of fluctuation zone in the upper reaches of the reservoir was not covered. Nearly one-half (72) of the sites have newly exposed or intact, buried deposits that clearly extend above the 487.7 m (1,600 ft) elevation. The Draper survey collected important information on past effects of reservoir raising and lowering of the pool level on archaeological sites and provided recommendations for future management of these endangered resources.

## **John Day Reservoir**

### **Geomorphic setting**

John Day Reservoir is located in the wide gorge of the lower Columbia River (Figure 4). Unlike many steep-sided river valleys that have been eroded over many thousands of years, the Columbia River Gorge was apparently excavated by a series of cataclysmic floods following the draining of large glacial lakes in Washington, Oregon, and Montana during at least one comparatively short period of several thousand years. The last series of these catastrophic floods occurred about 15,000 to 12,800 years ago. In the ensuing period, the lower Columbia River has developed a broad floodplain in the floor of the gorge and large alluvial and colluvial fans have prograded down the sides of the gorge and onto the floodplain.

Reservoir level fluctuations of 1.8 to 2.4 m (6 to 8 ft) in John Day Reservoir have focused their impact on a narrow band on the shoreline unlike the broad zone produced by 45.7 m (150 ft) of pool level in Dworshak Reservoir. The shoreline fluctuation zone in John Day Reservoir crosses the base of the valley sides near the dam and moves progressively lower in the landscape across low terraces and the floodplain as the pool extends upstream.

### **Cultural setting**

The John Day Reservoir includes some 209 known archaeological sites, including many large important occupations along the Columbia River. The reservoir also has a long record of archaeological investigations, extending back to 1938. The history of archaeological work at John Day was summarized by Draper (1992).

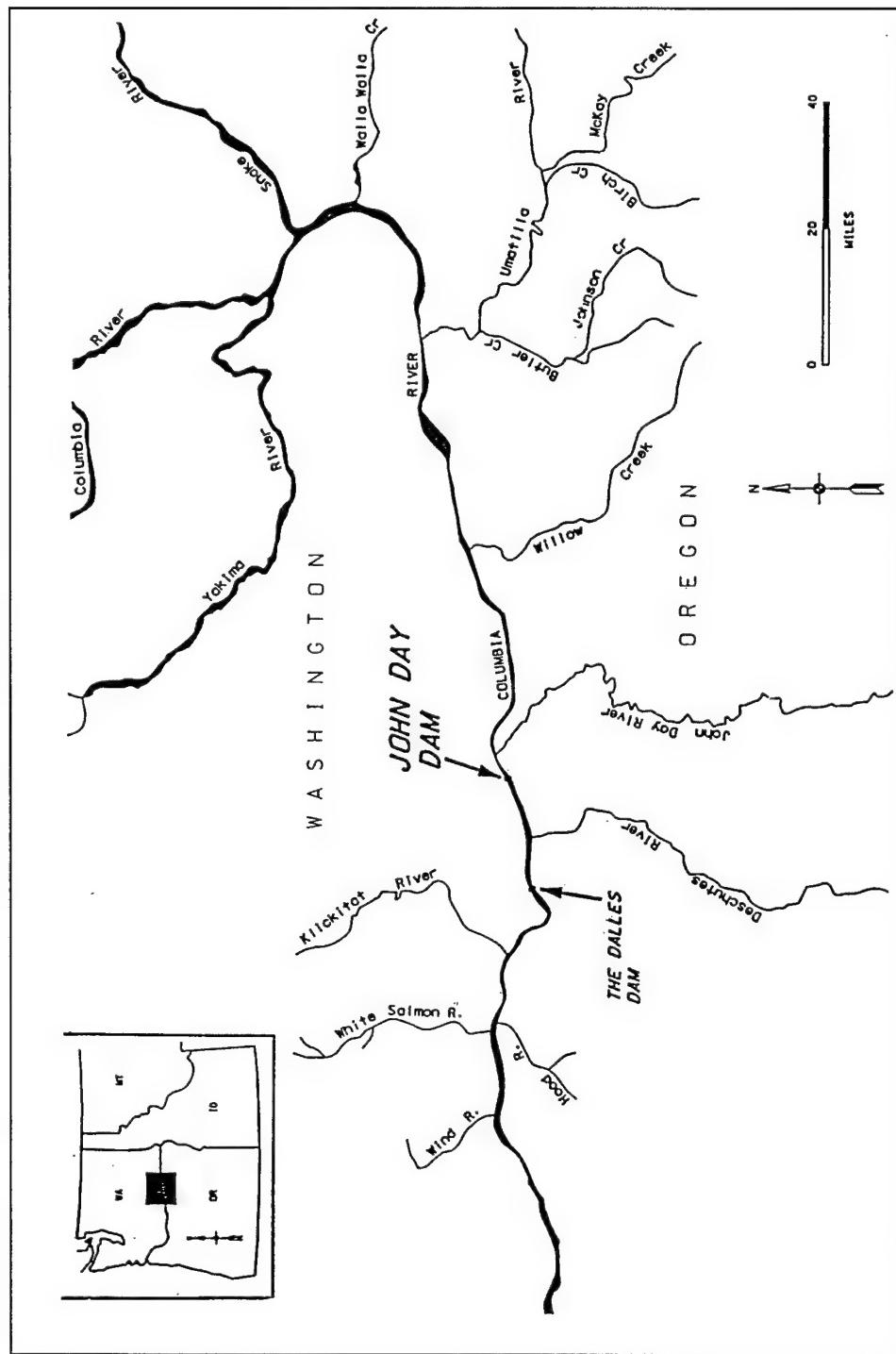


Figure 4. Location of John Day Reservoir, Columbia River

Although the reservoir fluctuation zone is small (1.2 m (4 ft)) compared to that at Dworshak, severe shoreline impacts to archaeological sites have been noted by many of the previous investigations. Along with erosion attributable to reservoir operation, loss of cultural artifacts and deposits due to site vandalism and collecting has been significant. Recent inspection of 30 sites in the reservoir (Center for Northwest Anthropology 1992) confirmed that shoreline erosion continued to be a major contributor to loss of cultural deposits at John Day Reservoir.

## **4 Geomorphic Procedure for Cultural Resources in Reservoir Areas**

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### **Geomorphic Impacts on Cultural Resources in Reservoir Areas**

Geomorphology is important to all aspects of cultural resource management including resource identification, evaluation, and management. The science of geomorphology includes the identification and delineation of landforms and land forming (geomorphic) processes, analysis of geomorphic processes, and the history of the development of the landscape. Identification of landforms is important in cultural resources management, because the location of the archaeological record is clearly related to the occurrence and distribution of landforms. Knowledge of the occurrence and distribution of geomorphic processes provides critical information for the subsequent analysis of the impact of these processes on the archaeological record. Information on the history of the development of the landscape is the environmental basis for the evaluation of cultural resources.

The various geomorphic processes of erosion and deposition may have profound impacts on the cultural resources that occur in the areas in which these processes are active. The occurrence of geomorphic processes is a product of the interaction of environmental conditions and processes. A large number of site factors influence the occurrence of geomorphic processes at any location. However, the local geologic, soils, topographic, vegetative, climatologic, and hydrologic conditions are the principal factors that must be considered in identifying, analyzing, and managing these potentially devastating phenomena.

In the identification, analysis, and management of the geomorphic processes that may impact cultural resources, it is important to recognize all of the processes that may occur, not simply areas of erosion and areas of deposition. Field examination of erosion processes in the two reservoirs indicate that at least five separate processes are active, each with different types of impacts, controlled by different factors, and requiring different management approaches. Similarly, at least three major types of depositional processes are active in the two reservoirs.

Development of monitoring and protection plans for cultural resources should be based on the understanding of the distribution and characteristics of the

geomorphic processes, which may impact the resources. As stated previously, the primary goal of the development of the analytical geomorphic procedure is to provide the geomorphic information critical to the development of monitoring and protection programs for cultural resources in Dworshak and John Day Reservoirs.

A reconnaissance study of both reservoirs suggested the field work should focus on Dworshak Reservoir. A geographic information system (GIS) incorporated data gained through field investigations with previous studies. The following information is applicable to other reservoirs in the Columbia River System, although much of it was derived from field studies of Dworshak Reservoir.

### **Factors influencing geomorphic impacts**

The occurrence of geomorphic processes is a product of the interaction of environmental conditions and processes and is responsible for preservation or destruction of cultural resources. Various factors affect the rate and degree of geomorphic impacts. Geology is essential in analyzing parent material, type of fill material, and engineering properties. Soil is of interest in determining moisture content, mineral stability, structure, and permeability. Climate may affect soil and geologic properties. Any changes in local climate that increase the humidity accelerate the rate of decay of exposed cultural resources. On the other hand, a change to a drier climate will aid in preservation of resources. Any variation in climate due to elevation or exposure to weathering can cause significant differences in geomorphic processes.

Topography or relief of an area will decrease or increase geological processes. The type of failure along the valley walls of the river is directly related to elevation. For instance, the impact of wave action is only visible at a lower elevation. At higher elevations, any ponding of water, whether man-made or natural, will affect the rate of geomorphic impacts. Geologic structure, such as bedding and faults, may impede movement of subsurface water as well as restrict development of a vegetative root system. The type and amount of vegetation and extension of the root system may alter the stability of the surface. Human activities have also been apparent in both impact zones. Delineation of impact zones will be discussed below in Identification of Geomorphic Processes. Campgrounds and recreation sites have sometimes been constructed over archaeological sites. Human influences, including steepening of the slopes through excavation, water diversion onto the slopes, and the placing of fill on the slopes, affect both the spatial and temporal distribution of mass movement.

### **Impacts of erosional processes**

Erosion, usually resulting from fluvial degradation or excessive precipitation in this area, is a continuous process and may destroy or alter archaeological sites. Even if resources are not destroyed, exposure of archaeological sites increases illegal artifact collection. Reservoirs create a unique erosional situation in that their impoundments create erosional shores on slopes previously unaffected by lacustrine processes, causing immediate and accelerated erosion and

sedimentation (Lawson 1985). Bank erosion results in the loss of vegetation, which serves as a protective cover over soil and sediment.

Although numerous factors influence the rate and occurrence of erosion, the primary cause of bank erosion is wave action (modified after Ebert 1989). During this study, wave action was the dominant process not only in occurrence but in extent of destruction as well (Figure 5). Wave action can be generated from wind, tectonism, and pool level fluctuation. Erodibility index of the soil and the slope of the surface also needs to be considered. Erosion exists in both zones of impact although reservoir fluctuations do not directly affect erosional processes or depositional processes of the indirect impact zone. Since most of the indirect impact zone is heavily forested, few geomorphological processes could be identified.

Surficial geomorphic processes include mass wasting of soil and rock from slopes, overland flow of runoff as “sheetwash” on hillslopes and other sloped surfaces, concentrated water flow in channels of gullies and small streams, wave attack along reservoir shorelines, and dispersion of saturated soil. In part, bank stability varies with fluctuation levels. Mass wasting is caused by various processes, including fluvial and aeolian, and results in downward movement of surficial material (Figures 6 and 7). Sites may be buried, if the site is located at the base of the failure, or may be completely destroyed, if the site is located along the slope. As material is moved to a lower elevation, the stratigraphic record and environmental context of the archaeological record are altered. Locations of sites on the landscape may also be altered by mass wasting.

Forest practices, especially those associated with timber harvest and road construction, have increased mass wasting on already unstable slopes (Figure 8). Overland flow, identified as sheetwash in the Dworshak GIS, occurs on hillsides during a rainstorm when surface depression storage and either, in the case of prolonged rain, soil moisture storage or, with intense rain, the infiltration capacity of the soil are exceeded (modified after Morgan 1986). Soil loss from sheetwash varies according to velocity and turbulence of the flow and is more prevalent in areas with little or no vegetation. Gully erosion is another major geomorphic process affecting archaeological sites. Gullies are steep-sided stream courses which experience ephemeral flows during rainstorms. The width and depth of gullies vary. Due to their erratic behavior, a relationship between sediment discharge and runoff is difficult to establish. Existence of gullies is mainly attributed to excessive rainfall or extensive clearing of vegetation.

Erosion in the study area was identified during field investigations and using aerial photography. To establish the rate of bank recession, historic photographs need to be acquired and compared with recent photographs.

### **Impacts of depositional processes**

The degree and type of deposition over an archaeological site will determine preservation or degradation of cultural resources. In most instances, deposition of sediment will aid in preservation of the archaeological record by forming a barrier between sites and destructive processes. Unfortunately, sedimentation



**Figure 5.** Example of wave impact along the shoreline, Dworshak Reservoir, Idaho



**Figure 6.** Mass failure in the high impact zone, Dworshak Reservoir, Idaho



Figure 7. Downward movement of material (soil and vegetation) along the failure plane, Dworshak Reservoir, Idaho

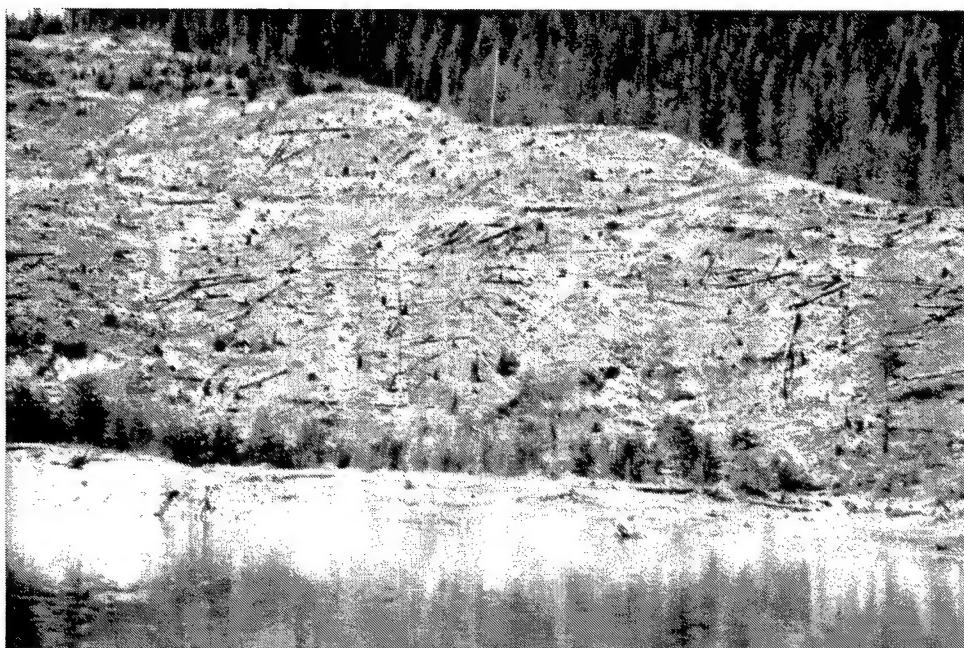


Figure 8. Logging in low impact zone, Dworshak Reservoir, Idaho

may also shield sites from shallow investigations and destroy fragile cultural resources. An understanding of sedimentation rate and sediment type and amount is important in evaluation of site preservation. To better understand these components of sedimentation, further studies, including radiocarbon dating and stratigraphic analysis, need to be conducted.

Three general types of deposition that occur in the two reservoirs are colluviation of mass wasting and soil dispersion deposits at the base of the slopes, fluvial deposition of sediments from sheetwash and channels, and lacustrine deposition of wave-eroded materials. Although deposition is an important process, erosion is more prevalent nearshore. Depositional and erosional processes exist nearshore but are also present in deeper waters. Initial dam construction and removal of sediment due to natural or man-made activities may alter the influx of sediment in the reservoir. Alteration of basin morphology as a result of sedimentation processes must also be considered.

### **Impacts of weathering and soil disturbance processes**

Soils in the North Fork drainage area have been described as brown podsolic soils comprised of light to dark brown humid and subhumid soils (Draper 1990). The process of soil dispersion consists of the mechanisms of soil infiltration and saturation, ionic exchange between soil and soil water to break soil bonding, and concentrated flow of the unbonded soil along concentrated soil moisture flow paths. Surface alteration resulting from weathering is apparent in aerial photographs and field investigations. However, soil disturbance can also result from subsurface water. Subsurface movement of water reduces the strength of soils and affects the soil characteristics. Weathering alters the physical and chemical characteristics of rock and soil at or near the surface. Movement of material by erosion accelerates the physical weathering process and is prevalent throughout Dworshak Reservoir. Freeze-thaw is another type of physical weathering apparent in this area although the effects are uncertain. Chemical weathering is dependent on the soil environment and chemistry of water moving through the soil. Alteration of mineralogical composition as a result of chemical weathering is usually identifiable based on color change of the parent material to the weathered material. The extent and type of weathering can be better evaluated with more extensive field investigations and laboratory tests.

## **Development of an Analytical Procedure**

In the following paragraphs, a brief description of the development of an analytical geomorphic procedure for use in management of cultural resources in the Columbia River System is given. The procedure has several objectives. The principal use of the procedure is to provide geomorphic information for developing monitoring and protection plans for cultural resources in impact zones of the reservoirs. The procedure must also be relatively simple and be supported by readily available information combined with some detailed information interpretation and field examination and verification. Finally, the procedure should be

developed such that it may be exported to other reservoirs in the Columbia River System. Construction of various databases is required by the proposed procedure in addition to identification of known geomorphic processes. A predictive model can then be established by incorporating these data into a management information system. In the following sections, the development of the procedure is outlined through a review of the conceptual basis for the procedure, construction of the databases required by the procedure, identification of geomorphic processes and process areas, compilation of a matrix of site conditions by geomorphic processes, and use of the procedure in other Columbia River reservoirs. The sequential steps of developing the procedure are illustrated in Figure 9.

### **Geomorphological information for cultural resource management**

The analytical geomorphic model followed sequential steps in constructing a basic model that can be used in management of a reservoir (Figure 9). A database pertaining to the geomorphology was first developed. Geomorphic processes were then identified from interpretation of existing maps, aerial photography, and video photography of the reservoirs at an altitude of less than 304.8 m (1,000 ft) from a helicopter. The video photography was used during field investigations of the more pronounced mass failures. Aerial photographs were later scanned and interpreted for use in a GIS. Unfortunately, photographs of Dworshak Reservoir were distorted and linkage between photographs was not possible. However, the photographs exist as a separate and important part of the geologic and geomorphic database. After identification and delineation of geomorphic processes active in the reservoir areas, the next step in development of the analytical procedure is development of a matrix of site conditions in the form of a GIS.

### **Development of geomorphological information**

The classification used in identification of slope movement processes is relevant to type of material, geographic location, rate and type of movement, resulting deposit, degree of development, and stage of activity. Classification used in identification of mass failures along the Columbia River and its tributaries is based mainly on type of movement and resulting deposits. The procedure for this classification includes field investigations, aerial photographic interpretation, and geologic and soil analysis. The study area encompasses a direct impact zone and an indirect impact zone (Figure 10). The direct impact zone is further subdivided into three divisions based on type of failure and elevation or location of the movement. The area at the lowest level (Level 1) is affected by wave attack from fluctuations in the reservoir. Above this level (Level 2), the drawdown of the reservoir still affects slope stability. Mass failures such as flows, slips, creep, and piping are evident. At the highest level (Level 3), influence of the drawdown on movement of material has decreased. Mass failures on a larger scale, such as gullying, rotational slides, and falls, usually occur at this interval. Differentiation of these zones was difficult in most areas and would require further extensive field studies.

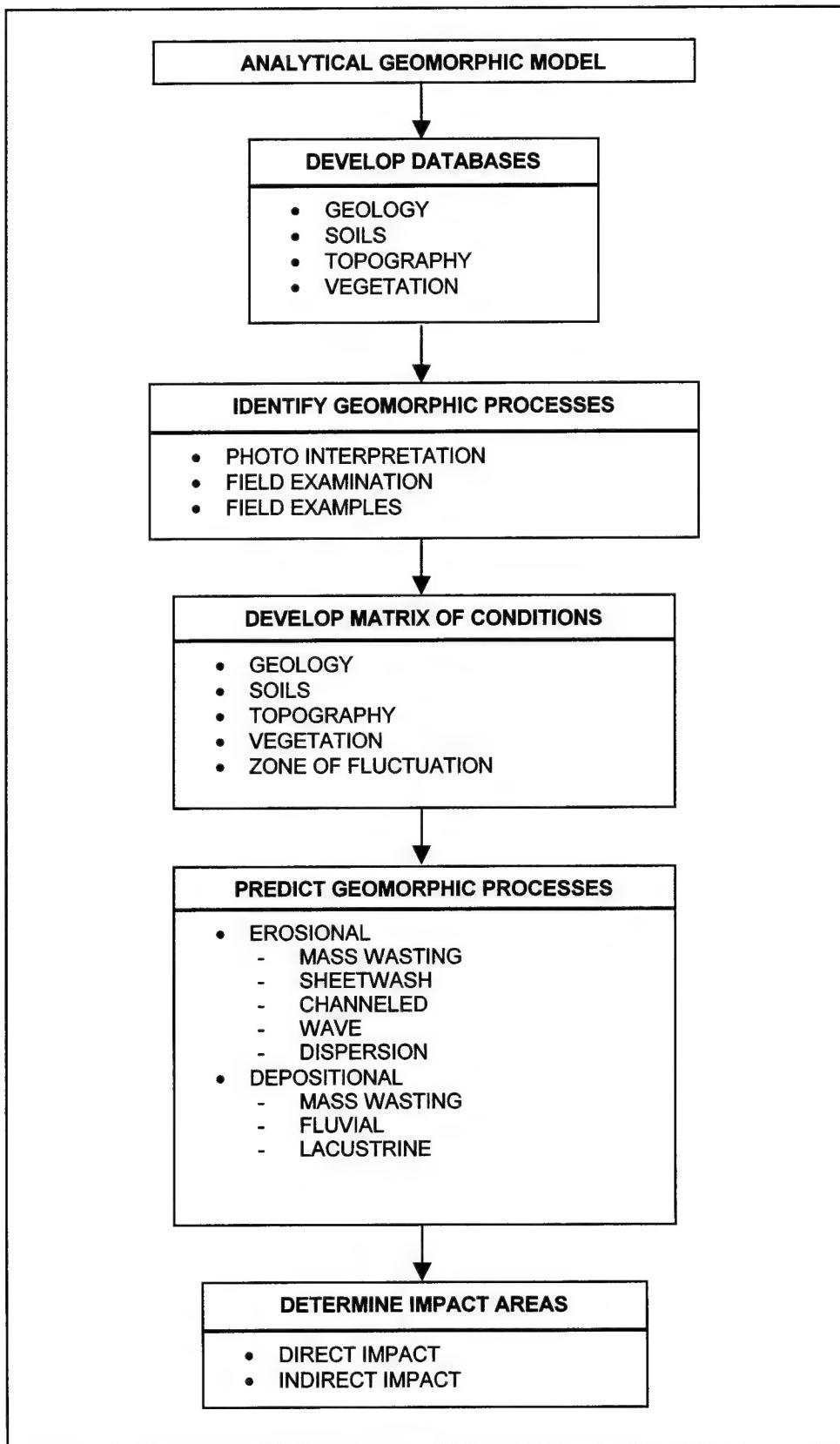


Figure 9. Sequential steps of an analytical geomorphic model

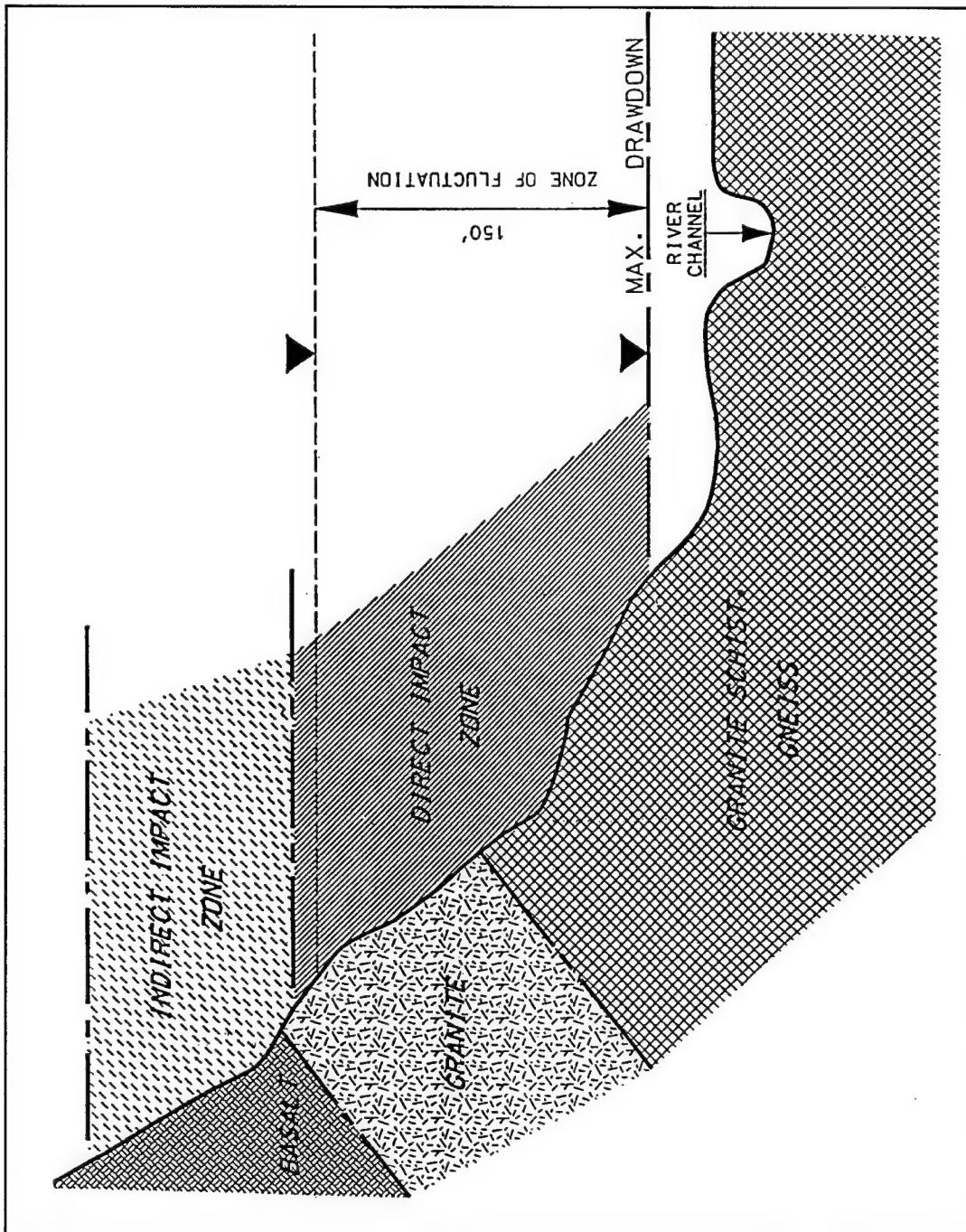


Figure 10. Division of study area into direct and indirect impact zones

## **Use of geographic information systems in impact analysis**

One of the most powerful tools for managing resources, which are distributed spatially and are relatively static, is the GIS. Using the relational database capability of a robust GIS and a well-conceived framework or model for simultaneous consideration of a number of environmental variables, the complex interactions of the factors which influence occurrence of geomorphic processes in the project areas may be analyzed and the distribution of the processes mapped. The environmental factors, which make up the GIS databases (geology, soils, topography, vegetation, etc.), may also be used for many other purposes in management and operation of the reservoirs. Although a GIS is not simply a database for constructing maps, it can create maps at different projections, scales, and colors.

The intent of the Dworshak Reservoir GIS is to provide support both in interpretation and maintenance of pertinent data concerning the reservoir environment. A GIS allows input, storage, manipulation, and analysis of spatially referenced data. The major analysis technique will be the combination or linkage of data layers to analyze or display spatial queries. For example, archaeological sites, mass failures, soils, and geology may all be combined to locate areas of high vulnerability for future failures. A buffer zone can be created to further section the high/medium/low failure sensitive areas.

The following is a list of digital databases assembles for the Dworshak Reservoir GIS:

*a. Raster maps.*

- (1) Topography.
- (2) Aerial photography.<sup>1</sup>

*b. Vector maps.*

- (1) Soils.
- (2) Geology.
- (3) Archaeological sites.
- (4) Slope failures.
- (5) Campsites.
- (6) Recreation areas.
- (7) Elevation.

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<sup>1</sup> After a significant attempt to rectify the aerial photography, it was determined that it was substantially distorted and could not be rectified because of the small number of known ground control points. Consequently, the aerial photography was not entered into the GIS for interpretation and use with the other data layers. However, the photography was scanned, geomorphically interpreted, and the interpretations entered into a database.

# Development of Databases

## Data requirements for the analytical geomorphic procedure

As mentioned above, many environmental factors influence the occurrence of geomorphic processes. Unfortunately, the scope of this project dictates that the analyses be completed primarily from readily available data in map form and the interpretation of some data sources such as aerial photographs. For this reason and following an initial reconnaissance of Dworshak Reservoir, it was determined that the analytical geomorphic model would be based on existing geologic, soils, topographic, hydrologic, and vegetative information, interpretation of aerial photographs, and field observation and verification.

## Source and characteristics of data requirements

**Geologic data.** Two sources of information were used to develop the geologic database. The most detailed existing geologic data for the two reservoir areas are U.S. Geological Survey geologic maps at the scale of 1:500,000. These maps show rock geologic units down to the formation level of differentiation. Definition of geologic conditions at sites in the two reservoir areas requires greater resolution than 1:500,000 necessitating a modest amount of field mapping of geologic formations in the two areas.

**Soil data.** Soil information was taken directly from existing 1:24,000 county soil maps generated by the U.S. Department of Agriculture (USDA) Soil Conservation Service for both areas. Both reservoir areas are mapped in the “Seventh Approximation” classification of soils. Data associated with the soil unit delineations include soil type, texture, engineering characteristics, and land-use capability.

**Topographic data.** The primary source of topographic information for the two reservoir areas is the 7.5 min (1:24,000) U.S. Geological Survey topographic quadrangles. Complete 7.5-min coverage exists for each area including undated quadrangles showing the extent of the reservoirs.

**Hydrologic data.** Water is a principal agent for geomorphic processes as it falls as precipitation, flows through the soil and underlying strata, fills interstitial pores in soils and sediments, increases the mass of the soil, runs over the surface in concentrated and unconcentrated flow, and washes against shorelines as waves. Some types of hydrologic data such as soil moisture and local precipitation are difficult and consequently expensive to obtain. Other types of hydrologic data like the location of streams and shorelines may be taken directly from maps and aerial photographs. This study focuses on the identification of the latter and the indirect consideration of soil moisture from the combination of soil and topographic data.

## **Identification of Geomorphic Processes**

### **Active geomorphic processes in the Columbia River System**

As presented above, field observations and examination of aerial photographs indicate that at least five erosional and three depositional processes, which may impact cultural resources, are active in the two reservoirs. The erosional processes include mass wasting of soil and rock from slopes, overland flow of runoff as sheetwash on hillslopes and other sloped surfaces, concentrated water flow in channels of gullies and small streams, wave attack along reservoir shorelines, and dispersion of saturated soil. Each of these processes is actually a series of discrete mechanisms controlled by site factors and energy inputs, which are interconnected to comprise the geomorphic process. For instance, the process of soil dispersion consists of the mechanisms of soil infiltration and (typically) saturation, ionic exchange between the soil and soil water to break soil bonding, and concentrated flow of the unbonded soil along concentrated soil moisture flow paths.

Unlike erosional processes, depositional processes may have a favorable impact on cultural resources through burial and partial protection. Deposition follows the erosional and transport (considered as part of erosion for this project) parts of a dynamic continuum on land and subaqueous surfaces. The three general types of deposition that occur in the two reservoirs are colluviation of mass wasting and soil dispersion deposits at the base of slopes, fluvial deposition of sediments from sheetwash and channels, and lacustrine deposition of mainly wave-eroded materials.

### **Identification procedure**

Identification of geomorphic processes in the reservoir areas follows a step-wise sequence. The initial step was identification and location of specific geomorphic processes in the field. During the reconnaissance of Dworshak and John Day Reservoirs, shorelines were viewed, photographed, and videotaped from relatively low altitude from helicopters. During these flyovers, locations of good examples of active geomorphic processes were identified for subsequent ground examination. Immediately following the flyovers, reservoir shorelines were examined from boats and over land where possible from road access. Particular attention was given to the positive identification and photography of the specific processes, site factors that influence the processes, and estimation of the impact of processes on cultural resources.

Upon return to the ERDC, Vicksburg site, the aerial photographs were examined and digitized for use in mapping the distribution of active geomorphic processes. Videotapes made during the flyover were also viewed to complete identification and mapping of the processes.

## **Delineation of process areas**

Upon completion of identification and mapping of geomorphic processes, distribution of various processes will be considered in the delineation of “process areas” where combinations of processes occur to comprise natural process areas. Delineation of these process areas will allow categorization of detailed shoreline geomorphology into discrete areas of the appropriate size for cultural resources management. The process areas will include differentiation of areas of direct impact (the maximum elevation of wave attack down to the minimum pool elevation) and indirect impact (a band of variable elevation extent, depending on site conditions) (Figure 10).

# **Predicting Geomorphic Processes and Impacts**

## **Development of a matrix of site conditions**

After identification and delineation of active geomorphic processes and process areas in the reservoir areas, the next step in the analytical procedure is the development of a matrix of site conditions in the form of a GIS database of environmental factors. Comparison of geomorphic processes with site conditions through the use of the GIS resulted in the definition of site characteristics required to produce specific geomorphic processes in the form of a matrix of specific processes versus site characteristics. This matrix formed the foundation for identification of processes (and consequently, impacts and management requirements) throughout the Columbia River System.

## **Prediction of geomorphic processes**

The prediction of geomorphic processes involves evaluation of existing and past processes and the parameters, i.e., soil type, geologic formation, slope, etc., contributing to their occurrence. The GIS can be used to form a model by combining attributes of individual layers. For example, the GIS can be queried to list the known processes occurring at a certain slope, on a particular soil type, and/or geologic formation. The list can be varied depending on the type and number of attributes. A matrix of conditions is established to provide a basis for predictive interpretation. The processes can then be categorized based on statistical probability. Although data will vary from each reservoir, the same procedure is applicable.

## **Prediction of impacts on cultural resources**

Destruction of archaeological sites by geomorphic processes can be best understood through development of a site model. Before a protection plan can be initiated, the type of geomorphic process, the degree and rate of destruction, and the archaeological content itself must all be considered. Initially, site destruction in the Dworshak Reservoir can be divided into two categories; geomorphic

processes occurring under natural conditions and geomorphic processes resulting from man-made actions. Establishing a matrix of site conditions from these considerations forms a model for identification of geomorphic processes. The GIS can easily locate areas of potential destruction once a matrix of site characteristics has been determined. By understanding the mechanisms behind these processes, future geomorphic impacts can be predicted and protection and/or stabilization methods can be implemented.

### **Use of the analytical procedure in other Columbia River reservoirs**

The procedure described is based upon a generic approach to the identification and analysis of the distribution of geomorphic processes, which may impact cultural resources. The procedure is also developed for two substantially different reservoir settings at Dworshak and at John Day and therefore is designed to deal with a variety of landscapes and site conditions. For these reasons, the procedure should be readily adaptable to other reservoirs in the Columbia River System when local conditions are considered.

# **5 Monitoring Procedure for Cultural Resources Management in the Columbia River System**

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## **Monitoring of Impacts on Cultural Resources**

Monitoring of changing cultural resource site conditions that may occur following decisions from the SOR effort for the Columbia River System will be critical for future management and protection of significant cultural properties. Modifications of operational procedures at individual reservoirs will impact archaeological and historical sites located in the zone of fluctuating water levels. As indicated in the previous chapter, geomorphic processes associated with reservoir operation already create serious problems for cultural resource integrity in these areas, and changing operational situations leading to increased drawdowns will exacerbate these impacts.

In addition to these physical processes, the potential for loss of or damage to sites can be anticipated to multiply from increased human activities in the exposed areas. Some of these expected impacts will be inadvertent, such as those that may occur because of visitation or recreational endeavors occurring on fragile exposed archaeological site surfaces. Others will result from intentional efforts such as vandalism or artifact collecting.

The brief test drawdown at Lower Granite Reservoir in March 1992 gave a clear and alarming preview of what can be expected to occur during drawdowns. There, artifact collectors immediately converged on newly exposed archaeological sites to acquire artifacts, often in full view of Corps of Engineers and other personnel. As one result of its field assessment of sites during the drawdown at Lower Granite and Little Goose Reservoirs during that time, the Washington State University field crew noted that every archaeological site located near access roads had evidence of pedestrian traffic preceding their visit (Center for Northwest Anthropology 1992). Boats were also used by artifact collectors to gain access to exposed sites. In addition to surface collecting activities, some vandals were observed using shovels and screens to retrieve artifacts before the sites were again inundated.

The archaeological sites exposed during these test drawdowns had been under water for nearly 20 years and, yet, when briefly exposed, were immediately set upon by collectors. The rate of site vandalism and artifact collecting can be anticipated to increase dramatically if periodic additional drawdowns are implemented on any of the Columbia system reservoirs. Each drawdown will yield freshly exposed artifact inventories that will be quickly and regularly exploited by collectors.

While some impacts derived from both physical processes and human-induced actions can be anticipated to occur with drawdowns, there is little or no extant quantifiable information that tells us exactly what this will mean for the resource sites at any given reservoir nor how it relates to long-term management needs for these resources. Only systematic monitoring of impacts and resource conditions will give us these badly needed data.

The term monitoring is fashionable today in environmental sciences and yet means many things in different fields and contexts. As used here, it refers to intermittent (regular or irregular) measurements or observations that, when analyzed and evaluated, offer a basis for making rational and sound management decisions for implementing proper and effective long-term preservation of the cultural resource record. Such a methodology is critical for identifying and understanding baseline resource conditions and protective needs under either changing or unknown circumstances, such as those represented by the combined effects of proposed drawdowns on archaeological sites. Once the baseline conditions are established and the relationships between the rate and magnitude of the various impacts are understood, recommendations for mitigation of both natural and human-caused impacts can be formulated.

Cultural resource monitoring is most beneficial when it results in more effective management decisions, to protect or preserve the archaeological and historic resources, which are considered important. Other uses of monitoring in this context include:

- a. Helping cultural resource managers determine compliance with Federal historic preservation laws and regulations and agency regulations.
- b. Constructing, adjusting, and verifying predictive impact models. These models become the tools used to evaluate and select resource protection strategies.
- c. Providing early warning of future resource protection problems when they can be resolved more easily and at a lower cost than if left unattended. Inadvertent loss of cultural resources data can be prevented through an effective monitoring program.
- d. Enhancing knowledge of past cultural events and patterns, their variability, and the impacts accruing from reservoir operations on this fragile database.

The goal of this chapter is to offer a recommended cultural resources monitoring procedure that, when implemented on a reservoir by reservoir basis, will

provide management of the information and framework to address potential loss of important cultural resources data associated with reservoir operation. Development of a strategy for cultural resource monitoring in the Columbia River System requires delineation of monitoring objectives and an overall approach. It also requires integration with the other two approaches outlined in this report, the analytical geomorphology, and site protection procedures.

## **Objectives of the Cultural Resources Monitoring Procedure for the Columbia River System**

Additional drawdowns from new or modified operational procedures at Columbia River System reservoirs will have adverse effects on cultural resource sites located in the zones of fluctuating water levels. Many of these resource properties are being impacted annually by existing reservoir operation. There is little or no precise information on these ongoing or potential impacts to sites, either at the general reservoir level or on a site-specific basis. Moreover, there are few data that help us chart trends in resource loss or the processes involved. There are no active cultural resource monitoring programs in place at any of the reservoirs to collect, analyze, and evaluate information on site impacts to aid in making long-term management decisions. What has been termed monitoring in the past (e.g., Center for Northwest Anthropology 1992) is not really monitoring but rather one-stop assessments to help establish resource conditions at a particular point in time. While such assessments are useful for identifying the current site conditions, if the data are collected in a functional manner, they do not provide a full rationale for making long-term management decisions nor can they produce information about changing conditions and trends over time.

The objectives of the Columbia River System cultural resources monitoring procedure accommodate acquisition of necessary long-term data on the various impacts and changing site conditions. They are as follows:

- a. Establish baseline conditions for significant prehistoric and historic sites located within the agency-controlled lands adjacent to the reservoir shoreline, especially those located within the presently defined or proposed drawdown zone.
- b. Develop and refine techniques to detect changes and to accurately quantify trends in cultural site conditions.
- c. Produce field validation for any modeling efforts associated with resource monitoring, such as prediction of certain impacts at given sites because of ongoing or changing reservoir operation, or changes in the rate and magnitude of such impacts.
- d. Provide managers with necessary information on resource conditions so that the most effective resource protection management options can be implemented.

- e. Yield insights into the effectiveness of agency cultural resources management policies and actions.

## **Conceptual Overview of the Columbia Basin Cultural Resources Monitoring Procedure**

The major components and their relationships necessary for developing a cultural resources monitoring program for a reservoir are shown in Figure 11. There are four basic levels of work involved in the monitoring procedure, including (1) compilation and evaluation of existing information; (2) design of an effective monitoring program based on the local natural and cultural setting; (3) implement monitoring; and (4) analyze and synthesize the incoming data. Each of these steps is briefly summarized below.

The initial step is to evaluate existing cultural resource database for the reservoir, including information such as site inventory records, available information on site condition, site evaluations, and adequacy of existing inventory coverage for the project. At Corps of Engineers lake projects, this information may be found in the project Historic Property Management Plan (HPMP), as well as supporting information contained in the cultural site files. Other sources of relevant information consulted should include available aerial photographs and maps, data concerning the natural environment, especially geological or geomorphological situations that have a bearing on cultural site protection, and a review of reservoir operating procedures as they relate to site protection.

Critical to this step is an honest and accurate assessment of the overall quality of existing information as it relates to the current condition and significance of sites, particularly those located in zones of fluctuating water levels that are receiving ongoing impacts. There are several questions that must be answered to assess the quality of the database. First, when and how were the original recordings done and what kinds of data were collected? In a majority of cases, the recorded data on file are neither current nor complete enough to state with certainty what is the present state of the resource. This is particularly a concern if the survey information is dated and a site has been subjected to ongoing impacts such as surface erosion, wave erosion, periodic inundation, or human-induced activities.

Another set of questions concerns the adequacy of existing information for making informed resource management decisions, particularly those involving resource protection and long-term preservation. In all likelihood, the original survey strategy did not include a full assessment of the agents impacting the site. Commonly, data on the site's condition have been updated on a systematic or comprehensive basis. An additional problem occurs when impacts to a given site or group of sites have changed over the years because of the effects of reservoir operation, changes in land use patterns, or different access conditions. The necessity for making more detailed and current site assessments for site protection needs is more fully covered in the next chapter.

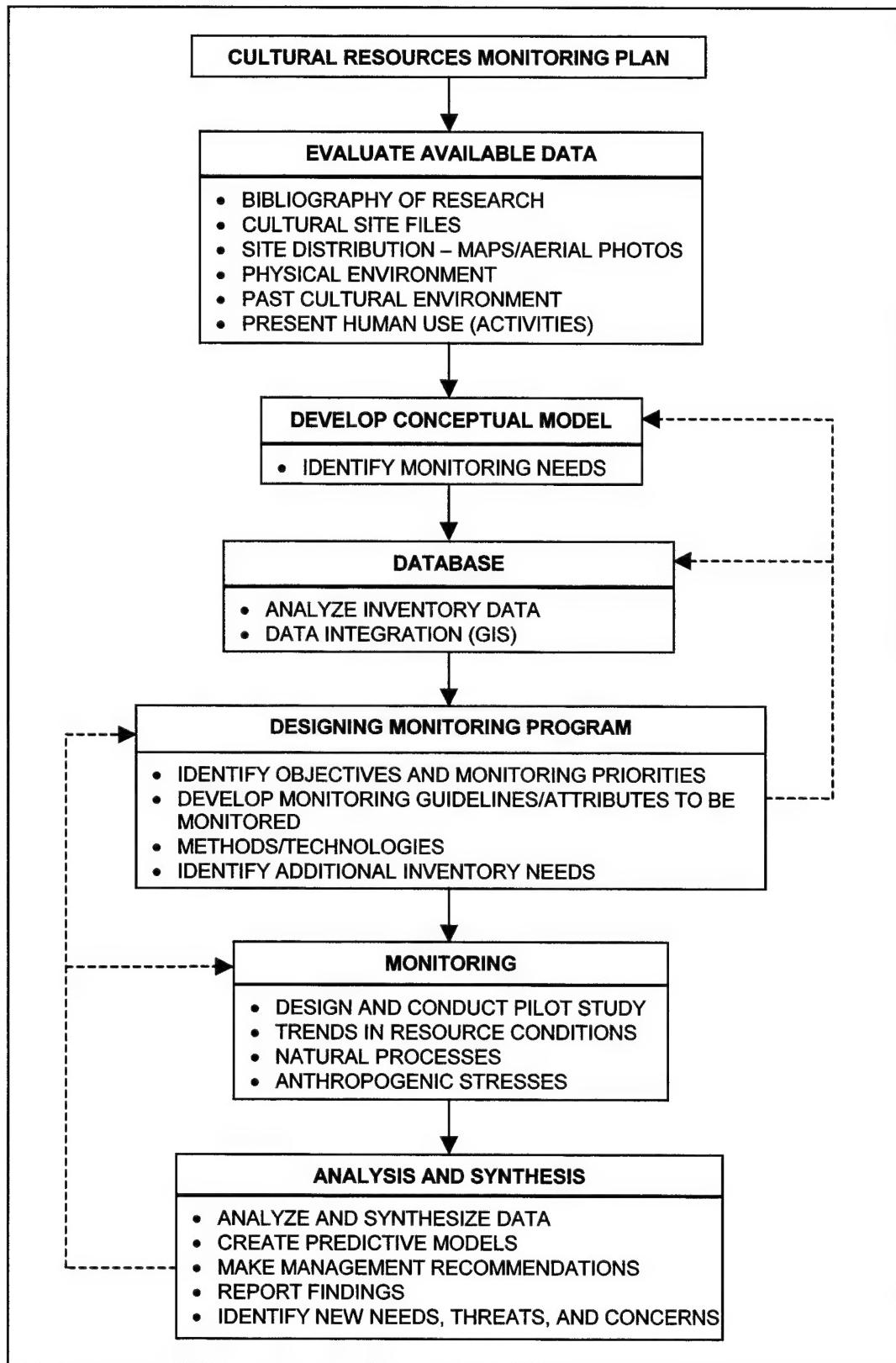


Figure 11. Developmental sequence for cultural resources monitoring plan

As part of this first step, general monitoring needs should be formulated, based both on the quality and timeliness of the existing data and the support for monitoring available within the organization. The support of the organization should be sought as early as possible in the plan formulation sequence. Failure to commit adequate resources of time, funding, and expertise to up-front design of the monitoring program and to the synthesis, interpretation, and reporting of information will result in probable failure of the entire effort. Moreover, this support needs to be established for the long-term so that the monitoring results contribute maximum benefit to the decision-making process.

A final factor that must be addressed early in the development of the monitoring program is integration of the data. At the project level, use of a GIS is recommended, especially if the monitoring procedure is to be integrated with the analytical geomorphic procedure discussed in the preceding chapter. Additionally, integration of the project-specific monitoring plan and similar efforts at other projects in the district should be accomplished, again employing a GIS database. Eventually, monitoring results at both projects and districts should be integrated and analyzed comparatively at the division or river-basin level. Integrative efforts will be enhanced if a standardized monitoring procedure is used as the basis for each project-monitoring plan.

The second major step in the monitoring process is the design of the reservoir-specific monitoring plan. This step involves delineation of the monitoring objectives and priorities for that particular project and its cultural resource database. It also includes identification of the precise conditions or attributes to be monitored, consideration of the most appropriate methods and technologies to be employed, and scheduling. An important outcome of this step and the previous one is identification of additional inventory (or reinventory) needs to complete the database. Within the context of the SOR, inventory and site condition assessments will certainly be required for areas exposed by future drawdowns that have not been inspected for years because of inundation or have never been given intensive examination.

Implementation of the next step, the actual monitoring approach, should begin with a pilot study to test and evaluate the overall program design. Both the pilot monitoring effort and the full monitoring program are designed to examine trends in resource conditions related to both natural processes, especially those related to reservoir operation, and anthropogenic stresses to cultural sites during exposure.

The fourth and final step in the monitoring procedure includes ongoing, periodic analysis and synthesis of the accumulated monitoring data. It is critical that the monitoring effort provide continual feedback to management of the resource base. Monitoring data can also be used to create predictive models for changing resource conditions that can be tested in subsequent years, along with identifying new needs, threats, and concerns that may not have been apparent earlier in the monitoring program.

## **Documentation for the Monitoring Procedure**

Proper documentation of the monitoring procedure objectives and design is critical to the long-term success of the overall effort. This documentation provides a protocol to guide the program and also records the data collection and analysis techniques in detail. This allows people to continue the monitoring process in future years and enables continuity and quality of subsequent data collection to be maintained.

The monitoring procedure should be documented at three levels within the historic preservation program: the HPMP, a reservoir-specific monitoring plan, and a site-specific monitoring packet. Each of these levels is described below.

The HPMP provides a comprehensive program to direct the historic preservation activities and objectives at each Corps project and to manage and protect each cultural resource site. As part of the HPMP, the goals and background information for the monitoring program should be fully described, including the relationships between the monitoring effort and other cultural resource management thrusts and priorities. By regulation, information from the HPMP is also incorporated into a higher level of planning, the master planning process, which is guided by the Master Plan and Operational Management Plan for a given project.

Below the HPMP level of documentation, but associated closely with it, is a recommended monitoring plan. A plan should be prepared for each reservoir project, to institutionalize the overall monitoring program for the long term. The last three steps of the monitoring process, the design of the monitoring program, implementation, and analysis and synthesis of the data, form the basis for the monitoring plan. The conceptual framework of the monitoring procedure outlined in the reservoir-monitoring plan should be viewed as being dynamic in nature, with continual feedback and reevaluation of the goals and objectives as both monitoring and additional inventory data are accumulated and synthesized. As field methods are further tested and experience allows for new insights, the monitoring plan should be reviewed and revised.

The monitoring plan should include an inventory of those sites at the project selected for monitoring, along a list of intrasite areas or features to be inspected at each site. Justified scheduling of the monitoring needs for each site should also be included in the plan.

Integral to the overall monitoring plan is the site-specific monitoring packet. The individual site packet is designed to be used onsite in the field to acquire site-specific monitoring data and to assure that those data are collected in a comprehensive and consistent manner. The packet should consist of three parts. The first contains a brief text describing site location, major features, past monitoring or other investigative activities, and recommendations for future monitoring. The second part of the site packet contains illustrations showing the site location, necessary details of the site layout, and black-and-white or color photographs of the general site area and specific details that must be inspected. These figures are used to help locate the site, indicate areas of special concern, and determine the

amount of deterioration because of impacts since the last visit. The third part includes a format for collecting the necessary data that are used to collect monitoring information. This site-monitoring checklist guarantees congruity and completeness in data acquisition.

## **Development of a Monitoring Plan for John Day Reservoir**

Development and implementation of a monitoring plan as described above requires a long-term management commitment to the resource base, and must be approached on a project-by-project basis. The level and adequacy of pre-existing information will be different for each reservoir in the Columbia River Basin and, as indicated in Chapter 4, the impacts of various geomorphic processes will differ greatly between projects. The following discussion looks at the John Day cultural resource database and identifies the initial steps necessary to formulate a management plan. This discussion is illustrative only and is not intended to be critical of the extant data and management practices at this reservoir. The cultural resources files for John Day were examined in January 1993.

### **Background**

Archaeological work along the reach of the Columbia River now included in the John Day Reservoir has a long history, beginning in the late 1930s. Work since that time has been sporadic, and since the dam was completed in 1971, often more project-specific than systematic. A total of 209 sites were recorded within the John Day project boundaries as of 1992 (Draper 1992). Of these, 194 sites were recorded by Corps of Engineers' cultural resources personnel in 1979 and 1980, although a survey report was not completed. The fieldwork was conducted on the 124-km- (77-mile-) long Lake Umatilla, between John Day and McNary Dams, and included the lower 16.1 km (10 miles) of the John Day River, which enters the Columbia upstream from the John Day Dam.

Based primarily on the 1979 and 1980 survey data, a cultural resource management plan (CRMP) was prepared in 1985, prior to guidance specified in Corps of Engineers Environmental Regulation 1130-2-438, "Project Construction and Operation, Historic Preservation Program," published in October 1987. This regulation formally established a historic preservation program for Corps' activities associated with construction, operation, and maintenance at Civil Works projects, including preparation of management plans for cultural resources at individual projects (called "Historic Property Management Plans" therein).

Although based on somewhat limited survey data that were dated in some cases (e.g., the then-current condition of individual sites), the CRMP was advanced for its time with regard to consideration of the need for and identification of potential techniques for protecting archaeological sites and thereby providing long-term preservation of the resource properties. The plan incorporated an assessment of the known sites, taking into account information on features

present, site condition and present use, accessibility, and impacts. It further stipulated a number of strategies and technologies that could be used to protect sites in specific instances. These approaches were wide-reaching and divided into two categories, as follows:

*a. Physical protection measures.*

- (1) Structural stabilization.
- (2) Streambank stabilization.
- (3) Vegetative propagation.
- (4) Buried obstructions (e.g., chain link fence).
- (5) Recovery of data.
- (6) Artifact affixing.
- (7) Electronic surveillance.
- (8) Patrolling.
- (9) Barriers.
- (10) Fire control.
- (11) Erosion control.
- (12) Signing.
- (13) Trail modification.
- (14) Monitoring.

*b. Administrative protection measures.*

- (1) Research.
- (2) Public information.
- (3) Consultation.
- (4) Preparation of cultural resource reports.
- (5) Curation of recovered materials.
- (6) Scientific utilization.
- (7) Withdrawal or use restriction.
- (8) Adaptive reuse.

This information was combined to yield evaluations of individual sites from which prioritized sites could be identified, along with recommendations for subsequent management of the resources.

## Evaluation of the Cultural Resources Management Plan and the 1992 Monitoring Project

While it could be considered state of the art at the time of its preparation, the John Day Reservoir CRMP has to be considered an example of an inactive management document, meaning that it serves no ongoing management function. The plan established a baseline in 1985, albeit using 5-year-old and limited data at the time. It did not include provisions for acquiring additional or updated information from the sites, for monitoring site condition, or for updating the plan itself. The evaluations of the National Register of Historic Places for the sites have not been completed, and information on the present condition of most of the sites is not available. Consequently, as of 1993 little had been accomplished in meeting the management recommendations offered in the 1985 CRMP. One cultural property, Old Town Umatilla, a National Register prehistoric and historic site located just below McNary Dam in the upper reach of Lake Umatilla, has been afforded protection from wave action (riprap revetment) and from vandalism and artifact collecting (fencing, signing, and patrolling).

None of the known archaeological sites at John Day has been systematically revisited since the original recording effort, with the exception of the 30 sites assessed by Draper (1992) as part of monitoring at Lower Granite, Little Goose, and John Day Reservoirs. While Draper's project was designated as a "monitoring" effort, it really served more to collect current baseline conditions for a limited number (less than 15 percent) of the reservoir project's total cultural resource site inventory. According to Draper (1992), selection of sites to be included in the field visitation phase of the work was based on several factors:

Our primary objective, therefore, was to gather as much information as possible from as many sites of differing function on both the Oregon and Washington sides of the reservoir. Because of the size of the reservoir, however, site access was considered the primary limiting factor due to time and cost constraints. Once again, because sites accessible by foot or road would be less costly to locate, record, and monitor, priority was given to those sites with easy access in the selection process. Such sites might also be likely to attract vandals, and monitoring would perhaps identify illicit activities, or even discourage such activities from occurring.

Draper concluded that most of the sites his crews visited at John Day are undergoing extensive erosion as a result of wave action undercutting the soft, sandy banks. He also noted recent evidence of illicit digging and artifact collecting at several of the sites visited during his project, along with impacts from past

construction activities and development of recreational facilities. Draper further provided National Register significant recommendations for 12 of the sites visited, and offered recommendations for preventing site vandalism and physical site protection measures. He also suggested that future similar investigations at each of the reservoirs include subsurface testing, cost effective site mapping techniques, and resurvey of selected areas at each reservoir.

## **Recommendations for Development of a John Day Site Monitoring Program**

Identification of ongoing impacts in the reservoir fluctuation zone at John Day Reservoir calls for an innovative and comprehensive management approach. A functional resource-monitoring program, developed with a geomorphically based impacts analysis and a resource-protection approach, will be a useful tool for identifying and quantifying continuing impacts to shoreline sites. These procedures will be especially useful if regularly scheduled drawdowns become standard practice at the reservoir as a result of the SOR Study.

The cultural resource database for John Day is a good candidate for development and implementation of a long-term monitoring program. Although it will be necessary to start at the beginning of the process outlined earlier in this chapter. For further monitoring, little of the existing information on individual sites is current. For example, since much of the information is 15 years old, it is not known how many of the previously recorded sites have been lost to erosion or destroyed by other activity(ies) in the intervening period. Additionally, significant evaluations have not been completed for most of the sites.

Thus, compilation of existing information is necessary at first, coupled with acquisition of field data about current status and condition of each known site. Part of this effort should involve an analysis of the completeness and thoroughness of the previous inventory coverage, along with delineation of areas not adequately covered. Importantly, identification of the need for future inventory and assessment of site condition must include newly exposed areas that result from any drawdowns below the normal low-pool level. For long-term management needs, it will be critical to gain information on unrecorded sites that have been inundated during the past 25 years and that may require ongoing monitoring during subsequent drawdowns. Another important early effort in this process would be an analysis of the John Day Reservoir shoreline in accordance with the recommended procedure outlined in Chapter 4 of this report. The geomorphic impact data, along with the baseline cultural site information, will provide a firm basis for developing the monitoring program.

# **6 Development of a Cultural Resources Protection Plan**

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## **Introduction**

Most cultural resource sites located along reservoir shorelines in the Columbia River Basin have already experienced some adverse impacts from reservoir-related operations activities. These impacts include loss of sediments and cultural context at sites resulting from various forms of shoreline erosion as well as loss of artifacts and damage to cultural features that can be attributed to collecting and vandalism activities on the part of visitors.

In order to fulfill the requirements of Corps of Engineers' historic preservation regulations, along with other pertinent Federal laws and regulations, mitigation of the effects of these impacts must be considered as they relate to reservoir operation. Loss of resources in this manner can be mitigated through one of two general approaches. These include (1) stabilization of the impacted resource to provide long-term in-place protection, or (2) removal of endangered cultural sites and features via data recovery efforts. In some cases, the two mitigative measures may both be employed where a particularly vulnerable portion of a site may be excavated while the remainder is protected.

Actual protection of the site that affords long-term preservation of the cultural materials is the preferred option, when conditions permit. If a suitable, cost-effective protective technology can be implemented; this management strategy leads to better overall conservation of the resource. It also meets the intent of the applicable historic preservation legislation, especially the National Historic Preservation Act of 1966, which focuses on stewardship of the resources rather than directed use.

## **The Cultural Resource Protection Plan**

The following paragraphs outline a procedure for developing a cultural resources protection plan. The proposed scheme can be applied to any of the reservoirs in the Columbia River Basin. Moreover, it can be developed at a given reservoir, or it can be applied to an individual site or small group of sites experiencing similar impacts.

The recommended approach for effective preservation of the resources is based on an integrated strategy that incorporates both the analytical geomorphic and the monitoring procedures discussed above. In the case of the site protection effort, a general cultural resources protection plan should be prepared for each reservoir, accompanied by an individual, more specific protection plan for each site requiring physical protection or those sites that have been protected.

Similar to the analytical geomorphic and monitoring efforts, a recommended developmental sequence is provided for a resource protection plan (Figure 12). This sequence is outlined below.

The first step in developing a functional resource protection plan is evaluation of the existing database. The key to arriving at an accurate listing of cultural resource sites that require protective attention lies in the quality of the site inventory for the project. Current information must be available for the significance of the individual resource properties, along with a general assessment of the likelihood that the site is endangered. Those sites that are eligible or potentially eligible for listing in the National Register of Historic Places face a likelihood of loss because of one or more impacting agents and are candidates for the resource protection plan.

The second event in the process involves assessments of the individual sites to gain current and accurate information on the archaeological content and condition of each site. This field phase is particularly important if the site was previously recorded. The field assessment should include an identification and evaluation of the kinds of impacts and their sources, as well as an estimate of the immediacy of the protection needs, given the impacts noted. It may be necessary to conduct limited archaeological testing to determine the extent and condition of the site's subsurface context. Specialists, such as a geomorphologist or hydraulic engineer, may have to assist in the evaluation of impacts.

Once the assessments have been completed for those sites included in the resource protection effort, the next step is to determine the best and most cost-effective approach to mitigating the resource loss. As noted above, in-place protection is preferred if feasible. In some cases, the nature of the impacts and the immediacy of loss may call for data recovery. In each case, however, both site protection and data recovery should be considered fully as alternatives and a fully supportable decision should be made for the mitigation approach at each site.

In the case of site protection, the next action is to determine the protection effort objectives, priorities, and management requirements. Included in this analysis is an evaluation of the potential site protection technologies available for use, based on the site conditions. Information on these topics has been developed by the ERDC and is available to aid resource specialists and managers in identifying the most practical and cost-effective protection strategy.

The final step involves design and implementation of the selected site-protection approach. It is imperative that the installation of the protective technology be intensively documented. It is also critical that the monitoring and

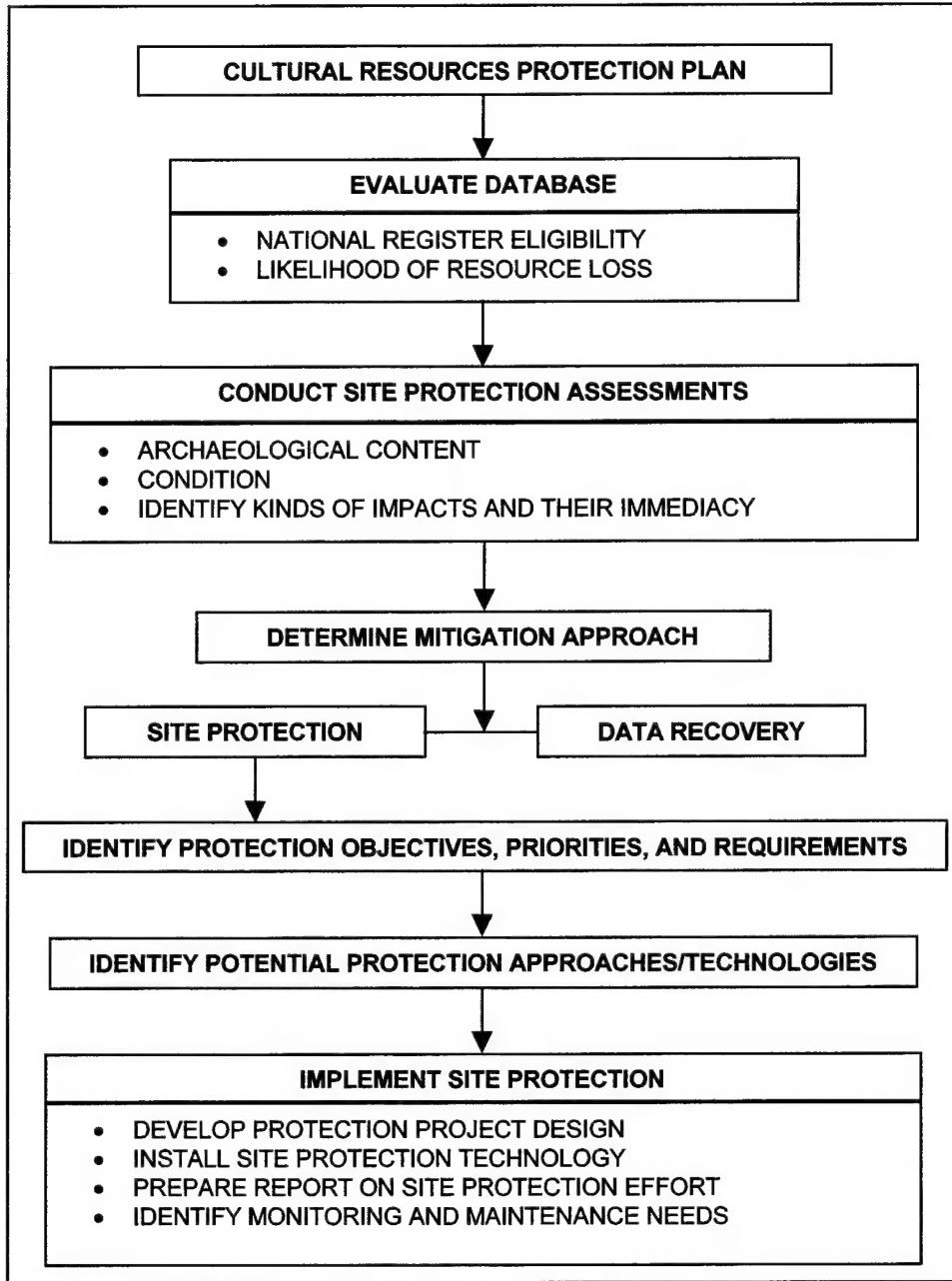


Figure 12. Developmental sequence for a resource protection plan

maintenance needs be identified during this phase and a long-term program for field checking of the protected site be outlined.

### **Initial development of a site protection plan for Dworshak Reservoir**

One objective of this study was to examine the cultural resource site protection procedure outlined above by using the Dworshak Reservoir archaeological site database. The reasons that the Dworshak sites were employed for this analysis are the availability of results from a fairly recent intensive survey of more than half of the extensive zone at the reservoir and the fact that the geomorphic procedure discussed in Chapter 4 was developed primarily using Dworshak information. Thus, it is possible to apply procedures to these resources to indicate how the process would work, both in an expanded version at Dworshak and at other reservoirs in the Columbia Basin.

The 1989 field inventory of the drawdown zone at Dworshak (Draper 1992) covered about 65 percent of the total shoreline extending upstream from the dam to river mile 34. The fieldwork was restricted to the lower and upper levels of the operational pool, 451.1 m (1,480 ft) and 487.7 m (1,600 ft), respectively. Thus, a significant portion of the total project area remains unsurveyed, including the entire area below 451.1 m (1,480 ft), the administrative lands above the high waterline, and the drawdown zone in the upper one-third of the reservoir. The 1989 survey recorded 166 new archaeological sites in the zone of fluctuating water levels and revisited four previously known sites. Each of these sites has been impacted to a varying extent as a result of ongoing annual raising and lowering of the reservoir pool since construction of the dam in the early 1970s.

Although the archaeological site picture is fairly well known for a good part of the reservoir and the geomorphic procedure has been developed at the macro level of scale, using existing cartographic, geologic, and aerial photo data, the following analysis is saddled with some limiting factors. First, aside from some reconnaissance-level inspection, little archaeological site-specific ground truthing of either current condition assessments or on-site evaluation geomorphic processes and resultant impacts has been accomplished. Second, the key component of the site significance evaluation aspect has not been satisfactorily resolved. Draper (1992) used an innovative ranking methodology to arrive at a score for each site under evaluation that was achieved by examining a number of variables that had been assigned a weighting factor. Whether or not the ranking holds up under further scrutiny is not evaluated here. However, the results of this ranking scheme have been questioned and National Register of Historic Places eligibility has not been entirely resolved for the Dworshak sites. The importance of this evaluative stage is that it must be settled before final decisions can be made regarding selection and prioritization of individual sites and subsequent implementation of protective features. Consequently, the following discussion is only a generalized example of how the procedures can be combined to contribute to informed management decisions, rather than a final analysis of the Dworshak data.

As outlined earlier in the report, development of the geomorphic procedure for Dworshak Reservoir involved identification and prediction of geomorphic

processes and impacts that might adversely affect archaeological sites. Part of that analysis combined a spatial identification of extant processes along with a spatial and vertical delineation of sensitivity zones. The former results in placement of active geomorphic processes on aerial photographs and the latter results in a GIS-based map of high-, medium-, and low-sensitivity zones for the entire reservoir setting. Once archaeological site locations are plotted and combined with this information, it is possible to identify and evaluate the interaction between site characteristics, geomorphic processes, and impact sensitivity.

The results of this combination for the Dworshak data are reflected in Table 1 which lists those sites and their characteristics that are threatened by a predominate observable geomorphic process. Also noted is the impact sensitivity zone in which each site lies throughout the reservoir. Based on the level of analysis possible at this time, there are 22 archaeological sites identified that fall into this category. During earlier evaluation by Draper (1992), only three of these were considered to be of National Register quality, two of which are in the medium sensitivity zone and the remaining site located in the low sensitivity zone. If, at this point, managers were confident in the cultural resources data and site evaluations, a short list of significant sites would be available that includes those most threatened. According to the procedure outlined in this chapter, the sites on this list would then be further evaluated through completion of on-site protection assessments that are designed to more precisely identify archaeological content, overall site condition, as well as better definition of the kinds of geomorphic processes affecting the remaining site integrity.

With all of this information in hand, managers would be prepared to make decisions concerning the most effective and cost efficient approach for mitigating loss of an important resource and its data. If in situ site protection and, hence, long-term preservation is feasible, these data will be invaluable for identifying and selecting the best protective technology, given the severity of specific impacts to the site under review.

At Dworshak, the sites in the previously inventoried areas have been adequately located and recorded, but the question of National Register eligibility needs to be resolved. Based on this preliminary analysis, however, archaeological sites 10CW500, 10CW562, and 10CW595 have been identified as sites with the highest potential for being significant while, at the same time, have been assessed as receiving critical impacts from observable geomorphic processes. The validity of these observations requires field verification.

### **Use of the site protection procedure at other reservoirs in the Columbia Basin**

By itself, the site protection procedure is applicable to other reservoir projects throughout the Columbia Basin and elsewhere. However, it is a more productive manager's tool for making informed decisions regarding archaeological site protection if employed in conjunction with the geomorphic and monitoring procedures outlined in this report. Whatever the situation, it is imperative that the

**Table 1****Archaeological Sites at Dworshak Reservoir Affected by Geomorphic Processes**

Site No.	Fluctuation Zone	Primary Process	National Register Eligibility (Draper 1992) <sup>1</sup>	Site Type	Elevation	
					Lower	Upper
10CW67	High	Debris slide/inundated	Not evaluated	Rockshelter/historic	1,400	—
10CW50 0	Medium	Wave action	Eligible (42)	Open camp	1,450	1,600
10CW50 3	Medium	Debris slide/Mass failure	Not eligible (39)	Open camp	1,490	1,600
10CW54 0	High	Sheet wash/Wave action	Not eligible (38)	Open camp/midden	1,520	1,600
10CW54 2	Medium	Sheet wash	Not eligible (31)	Open camp	1,500	1,600+
10CW56 2	Low	Sheet wash	Eligible (42)	Open camp/midden	1,490	1,600
10CW56 5	Low	Mass failure	Not eligible (35)	Open camp	1,530	1,600+
10CW57 1	Low	Sheet wash	Not eligible (31)	Open camp	1,530	1,600+
10CW58 9	Low	Sheet wash	Not eligible (25)	Open camp	1,550	1,600+
10CW59 5	Medium	Sheet wash	Eligible (42)	Open camp	1,450	1,600+
10CW59 8	Medium	Gullyng	Note eligible (36)	Open camp/historic	1,450	1,550
10CW59 9	Medium	Mass failure/Gullyng	Not eligible (28)	Open camp/midden	1,500	1,570
10CW60 0	Low/medium	Debris slide/Gullyng	Not eligible (20)	Open camp	1,500	1,600+
10CW60 1	Medium	Mass failure	Not eligible (28)	Open camp/midden/historic	1,450	1,600
10CW60 2	Medium	Wave action	Not eligible (21)	Open camp	1,520	1,600+
10CW60 6	Medium	Debris slide	Not eligible (31)	Open camp	1,480	1,540
10CW60 8	Low	Wave action	Not eligible (36)	Historic	1,500	1,600
10CW60 9	Low	Mass failure	Not eligible (7)	Open camp	1,500	—
10CW61 0	Low	Debris slide	Not eligible (13)	Open camp	1,550	1,600
10CW62 1	Medium	Wave action	Not eligible (26)	Open camp	1,475	1,600+
10CW64 2	Low	Gullyng	Not eligible (28)	Open camp	1,525	1,600+
10CW64 7	Medium	Gullyng	Not eligible (29)	Open camp	1,500	1,600+

<sup>1</sup> National Register evaluations from Draper (1992). Point totals result from analysis of several variables that yield ranked totals.

cultural resources database for the given reservoir project be up to date and that information of the current condition of individual archaeological sites be part of the decision-making process, as well as justified National Register evaluations.

# **7 Summary, Conclusions, and Recommendations**

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## **Summary**

This report describes conceptual development of a technical framework for addressing management needs for cultural resource properties that may be adversely affected by operation of reservoirs in the Columbia River Basin. The procedures outlined in this study are designed to aid resource managers and specialists faced with the possibility of changing operational conditions at reservoirs included within the SOR evaluation effort. These operational changes may include additional drawdowns of the pool levels and/or different scheduling of such events. The potential for an associated increase in impacts to archaeological sites located within the fluctuation zone ranges from exposure of sites that have long been inundated to repetitive raising and lowering of the pools across fragile archaeological contexts.

Three procedures have been developed as part of the present effort. These include (a) an analytical geomorphic procedure designed to permit identification of both processes and resulting impacts to archaeological sites, (b) a monitoring procedure that can be used to acquire critical data on long-term integrity of the sites, and (c) a site protection procedure to aid in evaluating and identifying appropriate protective technologies and long-term preservation options. The procedures are expected to be used at both primary types of reservoirs found along the Columbia River and its tributaries. One of each type of reservoir, including John Day as a run-of-river pool and Dworshak as an example of a storage project, have been included in the analysis. The procedures are, however, designed so that they may be used at other reservoir projects in the Columbia River Basin, as well as other similar reservoir projects throughout the country. The technical procedures are also designed to be compatible with and to support the goals of the HPMP required for each reservoir of the Corps of Engineers.

## **Conclusions**

Addressing issues similar to those for which the geomorphological, monitoring, and archaeological site protection frameworks have been developed is a

common and ongoing need at Corps of Engineers reservoir projects around the country. In the Columbia River Basin, the SOR analysis has brought the conflict between reservoir operation and cultural resource management into clear focus. Questions about what will happen to archaeological contexts with remaining physical integrity that happen to be located in zones affected by operational considerations involving episodic or special drawdowns are faced by reservoir managers and resource specialists on a continual basis. Often, the existing database for archaeological site inventory is only minimally adequate for making management decisions about long-term preservation of the resource base. Rarely are there adequately collected data about the current condition of the resource, nor an awareness of the conditions and processes to which the sites are subjected to as a result of reservoir operation. Even rarer still are proactive attempts undertaken to preserve either the data contained in sites or the sites themselves.

## Recommendations

Each Corps of Engineers District involved in the SOR analysis—Portland, Seattle, and Walla Walla—should evaluate the status of each reservoir project in view of implementing the procedures outlined in this report.

Each District should also examine the status of the required HPMP for each reservoir and consider incorporation of the technical procedures outlined in this report.

Critical to implementation and incorporation of these procedures is completion of a critical review of the current cultural resource database for each reservoir, including an assessment of the inventory data needs for each project and a careful review of the knowledge regarding status of the current condition of each previously recorded archaeological site.

If cultural resource properties located in reservoir drawdown zones in the Columbia River Basin are to be protected, much additional information about various processes affecting those sites will be required. While this effort has focused primarily on the physical impacts from naturally occurring geomorphological processes and those created as a result of reservoir operation activities, other processes also need to be addressed. These include possible chemical and biological mechanisms that may interact to cause loss of significant cultural resource data along reservoir shorelines, especially under changing operational conditions.

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<b>14. ABSTRACT</b> <p>The U.S. Army Engineer Research and Development Center developed a technical framework for identifying, evaluating, and mitigating impacts to cultural resource sites affected by reservoir operation in the Columbia River System. Components of this framework include geomorphic analysis, resource monitoring, and site protection procedures.</p> <p>Geomorphic analysis encompasses identifying active erosional processes in the vicinity of a reservoir, and defining how these processes will change when operational procedures for the reservoir are changed. Cultural resource monitoring occurs at four levels: compiling existing information; designing a monitoring program based on site-specific data; implementation of monitoring; and synthesis and analysis of data derived from the monitoring. The protection plan can be tailored to either storage-type or run-of-river reservoirs. It may involve long-term protection in place, or removal of endangered cultural sites.</p> <p>Changing operational procedures at each Corps reservoir has the potential to impact cultural resources. Development and implementation of a cultural resource management plan should mitigate some of the negative impacts.</p>					
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